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Haec Credimus

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested on the seventh. —Exodus 20:11

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Unknotting the Nucleus: Regulation and Domain Modularity of Type II Topoisomerases

Joseph E. Deweese* and Salvador Cordova**

Abstract

Routine cellular processes such as transcription, replication, and cell division result in knots, tangles, and torsional stress in DNA. All living organisms produce proteins known as topoisomerases to alleviate these DNA topology challenges, which can lead to cellular dysfunction or death if unresolved. Type II topoisomerases manage DNA topology by generating a transient double-stranded DNA break in one segment of DNA and passing another segment of DNA through the break before resealing the broken DNA. Human type II topoisomerases are well-characterized anticancer drug targets, but there are severe off-target toxicities often associated with some of these drugs. Humans have two versions of topoisomerase II, and it is of clinical interest to selectively target one version of topoisomerase II in humans. Selective targeting requires a thorough understanding of the differences between the two versions, and the evidence presented here explores some of the key pieces of information regarding these differences including genomic, amino acid sequence, modification, and interaction data. We argue that the two versions of topoisomerase II differ in key regions that also are heavily modified via post-translational modifications, which may provide key insights into the regulation and separation of function between the two isoforms. Finally, we suggest that protein domains display modularity that may help us understand the design of these and other proteins by analogy to the idea of a dependency graph.

Introduction

Biochemistry is a fascinating discipline that involves studies at the interface

of biology and chemistry through examining the structure and function of the four main classes of fundamental

biological molecules: carbohydrates, lipids, nucleic acids, and proteins. In the cellular world, vast arrays of complex biomolecules interact in an elegant and highly sophisticated manner to carry out the various processes that separate living cells from inanimate matter. It is within this submicroscopic realm that protein machines called enzymes operate.

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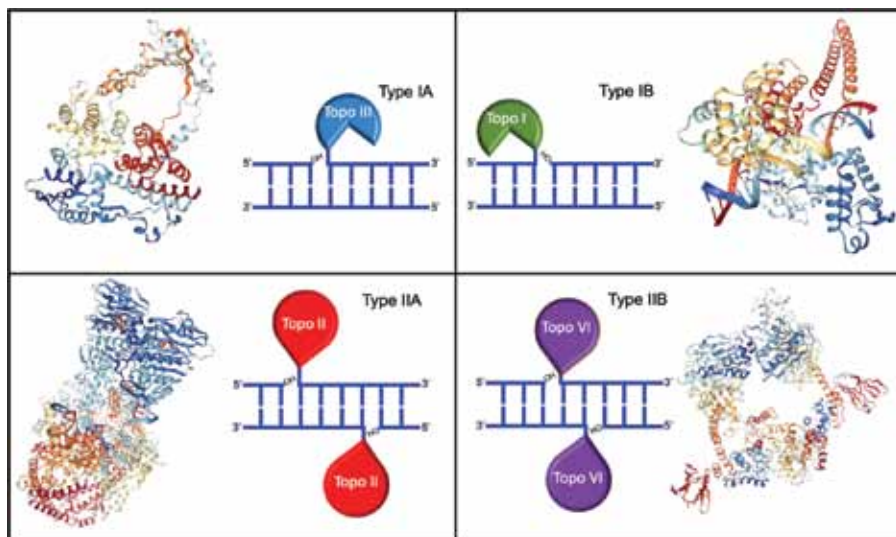


Figure 1. Families of Topoisomerases. Four of the five families of topoisomerases are represented with example structures at left or right. A diagram depicting the specific locations of DNA cleavage by each family and the location of the temporary covalent bond formed (either with the 5' or 3' end of the cleaved DNA) are shown using shapes linked to the DNA. Note: the diagrams do not show the full enzyme, but instead display a shape representation of a part of the enzyme. Structure images were derived from the Protein Databank (RCSB.org) with the structure file noted in parentheses as follows: Type IA: *E. coli* topoisomerase III (1D6M); Type IB: *H. sapiens* topoisomerase I (1A36); Type IIA: *S. cerevisiae* topoisomerase II (4GFH); and Type IIB: *M. maei* topoisomerase VI (2Q2E).

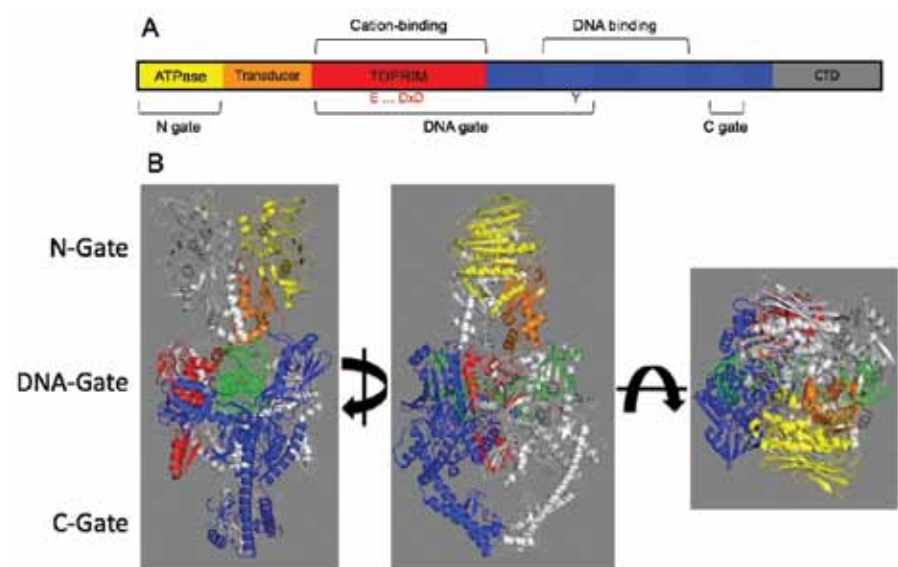


Figure 2. Domain and Biochemical Structure of Type IIA Topoisomerases. A) The domain map of a type IIA topoisomerase is depicted with some key regions identified along with key catalytic (Y) and metal-binding residues denoted (E...DxD). B) Ribbon diagram based upon the crystal structure of *S. cerevisiae* topoisomerase II (RCSB 4FGH). One protomer is color-coded with the domain map. The other protomer is grey. Structure images were generated using Pymol.

Enzymes are responsible for catalyzing the very reactions that make it possible to harness energy from food, build new biomolecules, copy DNA, and many other routine cellular processes. Due to their critical roles, enzymes are also effective drug targets from a pharmaceutical perspective.

Cancer is one example of a disease where using specific drugs to target enzymes can be very effective. In fact, for several decades, drugs like doxorubicin and etoposide have been used to fight cancer (Murphy et al., 2017). Both of these drugs happen to impact the same enzyme found in the nucleus of cells: DNA topoisomerase II. There are a handful of other drugs that also impact topoisomerase II for the treatment of cancer, and there are additional drugs (e.g., levofloxacin) that target bacterial type II topoisomerases (DNA gyrase and topoisomerase IV) for the treatment of infections (Pommier et al., 2010).

While agents targeting topoisomerase II are effective, they are not without side effects (or adverse events, as they are called in the medical field). Anti-cancer drugs that target topoisomerases are often associated with some of the well-known side effects of chemotherapy like hair loss, gastrointestinal problems, and others. These effects are common to most drugs that impact enzymes/proteins involved in cell division and/or DNA function. Unfortunately, these effects are not necessarily the most concerning. For example, etoposide treatment is associated with a risk for developing acute myeloid leukemia (Pendleton et al., 2014). In other words, when a patient is treated with etoposide, there is a chance that the drug may actually cause a different cancer (called a secondary or treatment-related disease). Additionally, doxorubicin is a member of a class of drugs known as anthracyclines, which are associated with cardiotoxicity and have a lifetime dose limit maximum to reduce the risk of toxicity (Zhang et al., 2012; McGowan et al., 2017).

Both etoposide and doxorubicin have been extensively studied in the literature, but open questions still remain about the exact mechanism behind these adverse events. Therefore, it is critical to carefully examine the precise mechanisms of drugs to predict and possibly avoid some of these extreme side effects. Our work focuses on type II topoisomerases to explore their function in cells and to explore whether new agents can be developed that help avoid some of these toxicities.

In this manuscript, we will explore the structure and regulation of topoisomerases, and we will provide some reflection on possible novel targeting mechanisms, as well as implications for what these enzymes mean for a design perspective. Using a design-inspired viewpoint, we will examine enzymes as modular proteins and consider implications of a modular perspective on discovery of protein functions and the development of targeted therapeutics.

Topoisomerases: Regulators of DNA Topology

Topoisomerases are a family of enzymes that resolve topological challenges in DNA. These enzymes have been found in all three domains of living organisms and are even found in the genomes of some viruses (McClendon et al., 2006). Topoisomerases regulate DNA topology by generating transient single- or double-stranded DNA breaks. The first topoisomerase to be discovered was initially named the ω protein (Wang, 1971) and later became known as topoisomerase I (Wang et al., 1979). A few years later, DNA gyrase was found (Gellert et al., 1976) and later named topoisomerase II, though gyrase is still the common name (Wang et al., 1979). This naming turned out to be quite fortuitous since type I enzymes generate a single-stranded DNA break while type II enzymes form a double-stranded DNA break (Figure 1).

This has become the naming convention of the now five families of topoisomerases (Table 1). As seen in Table 1, type I and II enzymes are divided into families (IA, IB, etc.). For example, topoisomerase III is a type IA while topoisomerase IV is a type IIA. This classification system accounts for structural and biochemical characteristics. As depicted in Figure 1 and listed in Table 1, several different mechanisms (single- vs. double-strand break, 5' versus 3' linkage, spacing between breaks) are utilized by different families of topoisomerases. While the type I enzymes are a fascinating study, we will be focusing on the type IIA enzymes for the remainder of this review.

Type II Topoisomerases

Type II Topoisomerases are divided into two major families: IIA and IIB (Figure 1, lower portion). While Type IIB topoisomerases are present in some organisms, the Type IIA topoisomerases are apparently more abundant in nature, and the enzymes encoded in the human genome are Type IIA topoisomerases (as discussed below). Type IIA topoisomerases, known generically as topoisomerase II, are dimers or tetramers meaning these enzymes are made from two or four separate protein chains. In the case of Type IIA enzymes in eukaryotes, the enzymes are typically dimers with two copies of the same protein chain coming together to form the functional enzyme. In archaea and bacteria, the enzymes are generally tetramers with an A2:B2 structure meaning two copies of each of two different proteins. For example, DNA gyrase is a type II topoisomerase in bacteria, which is formed by two copies of the protein GyrA and two copies of GyrB.

The organization of the protein domains within topoisomerase II is similar across organisms. As seen in Figure 2A, common protein domains including the ATPase, TOPRIM, and other domains are shown. The organization of prokary-

otic enzyme protein domains generally matches that of the eukaryotic proteins, except that the prokaryotic versions have separate protein chains for each half.

X-ray crystallography has enabled the acquisition of high-resolution structures of type II topoisomerases (Dong et al., 2007; Schmidt et al., 2010; Schmidt et al., 2012). This information has provided detail on how these protein domains relate to each other. As seen in Figure 2B, the ATPase domain is at the "top" while the TOPRIM and DNA binding domains are found in the middle. The protein then loops down to a lower domain (C-gate) before looping back up the sides. What is not present in this structure is the C-terminus, which is thought to exist on either side of the enzyme like a pair of "ears" or "wings." However, due to the relatively flexible nature of this domain, the crystal structure of the C-terminus has not yet been resolved.

Topoisomerase II performs a complex catalytic cycle that involves a series of steps and movements (Figure 3). First, topoisomerase II binds to a helix-helix cross-over, which may be formed by separate chromosomes or segments of the same DNA molecule (Zechiedrich et al., 1990; Roca et al., 1993). Second, topoisomerase II bends one of the two DNA segments and creates a temporary double-strand break (Deweese et al., 2009; Schmidt et al., 2010). The broken segment is called the gate segment. During the process of cutting the gate segment of DNA, topoisomerase II forms a covalent bond between an active site tyrosine amino acid and the 5' ends of the broken DNA segment (Liu et al., 1983; Sander et al., 1983; Zechiedrich et al., 1989; Mueller-Planitz et al., 2008; Schmidt et al., 2010). Due to the symmetry of topoisomerase II, this occurs with a four base-pair stagger, as depicted in Figure 1. As the DNA is bent and cleaved, topoisomerase II binds to ATP, which "closes" the top portion of the enzyme, called the N-terminal gate or

Table I. This table depicts families of topoisomerases and representative examples. Type I topoisomerases temporarily cut one strand while type II topoisomerases temporarily cut both strands of the double helix. Domains where specific enzymes are found are denoted: A, archaea; B, bacteria; E, eukaryote. Linkage refers to the phosphotyrosine covalent connection between the topoisomerase active site and the cleaved DNA. Activity is classified by the ability to support relaxation (rel) or supercoiling (sup) and the direction of supercoiling is denoted: - for negative supercoils and + for positive supercoils. Question marks represent information that has not been determined or where results may differ between organisms. Representative species are denoted. It should also be noted that there are viral topoisomerases in the IA, IB, and IIA families that are not shown in the table.

Family	Enzyme	Rep. Species	Linkage	Mechanism	Cofactors	Activity
IA	topoisomerase I (B)	<i>E. coli</i>	5'	enzyme-bridged strand passage	Mg ²⁺	rel -
	topoisomerase III (α, β) (E)	<i>H. Sapiens</i>				
	topoisomerase III (A, B)	<i>E. coli</i>			Mg ²⁺ , ATP	sup +
	reverse gyrase (A)	<i>Sulf. acidocaldarius</i>				
IB	topoisomerase IB (E, B)	<i>H. sapiens</i>	3'	controlled rotation/swiveling	none	rel ++
	topoisomerase IB mitochondrial (E)					
IC	topoisomerase V	<i>M. kandleri</i>	3'	controlled rotation/swiveling	none	rel ++
IIA	topoisomerase II (E)	<i>S. cerevisiae</i>	5'	double-strand passage, 4-bp overhang	Mg ²⁺ , ATP	rel ++
	topoisomerase II (α, β) (E)	<i>H. sapiens</i>				
	topoisomerase IV (B)	<i>E. coli</i>				
	gyrase (A,B)	<i>E. coli</i>				sup -
IIB	topoisomerase VI (A, E)	<i>Sulf. Shibatae</i>	5'	doubles-strand passage, 2-bp overhang	Mg ²⁺ , ATP	rel ++
	topoisomerase VIII (B, A)	<i>A. degensii</i>	?	?	Mg ²⁺ , ATP(?)	rel -

N-gate (Lindsley et al., 1993; Roca et al., 1993; Classen et al., 2003; Wei et al., 2005; Bendsen et al., 2009; Schmidt et al., 2012). Third, with the N-gate closed, topoisomerase II pulls apart the gate segment, forming the DNA gate. The other segment of DNA, called the transport segment, transverses through the DNA gate (Osheroff, 1986). Fourth,

the N-gate undergoes a twisting conformational change that appears to be accompanied by the hydrolysis of one ATP molecule (Roca et al., 1992; Lindsley et al., 1993; Harkins et al., 1998; Baird et al., 1999; Schmidt et al., 2012), which may prevent the transport segment from back-tracking to the N-gate (Schmidt et al., 2012). Fifth, the DNA gate can

now close and allow the opening of the “bottom” of the enzyme, called the C-terminal gate or C-gate (Osheroff et al., 1987; Robinson et al., 1991; Bromberg et al., 2002). This occurs along with the hydrolysis of the second molecule of ATP (Roca et al., 1992; Lindsley et al., 1993; Harkins et al., 1998). Closing of the DNA gate also allows for the

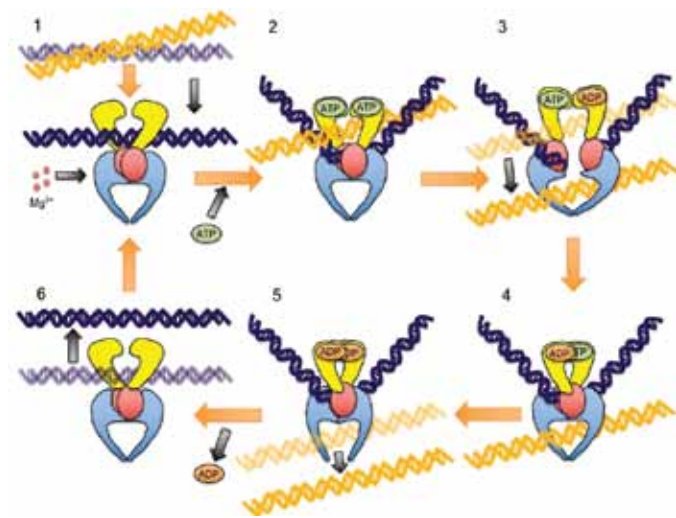
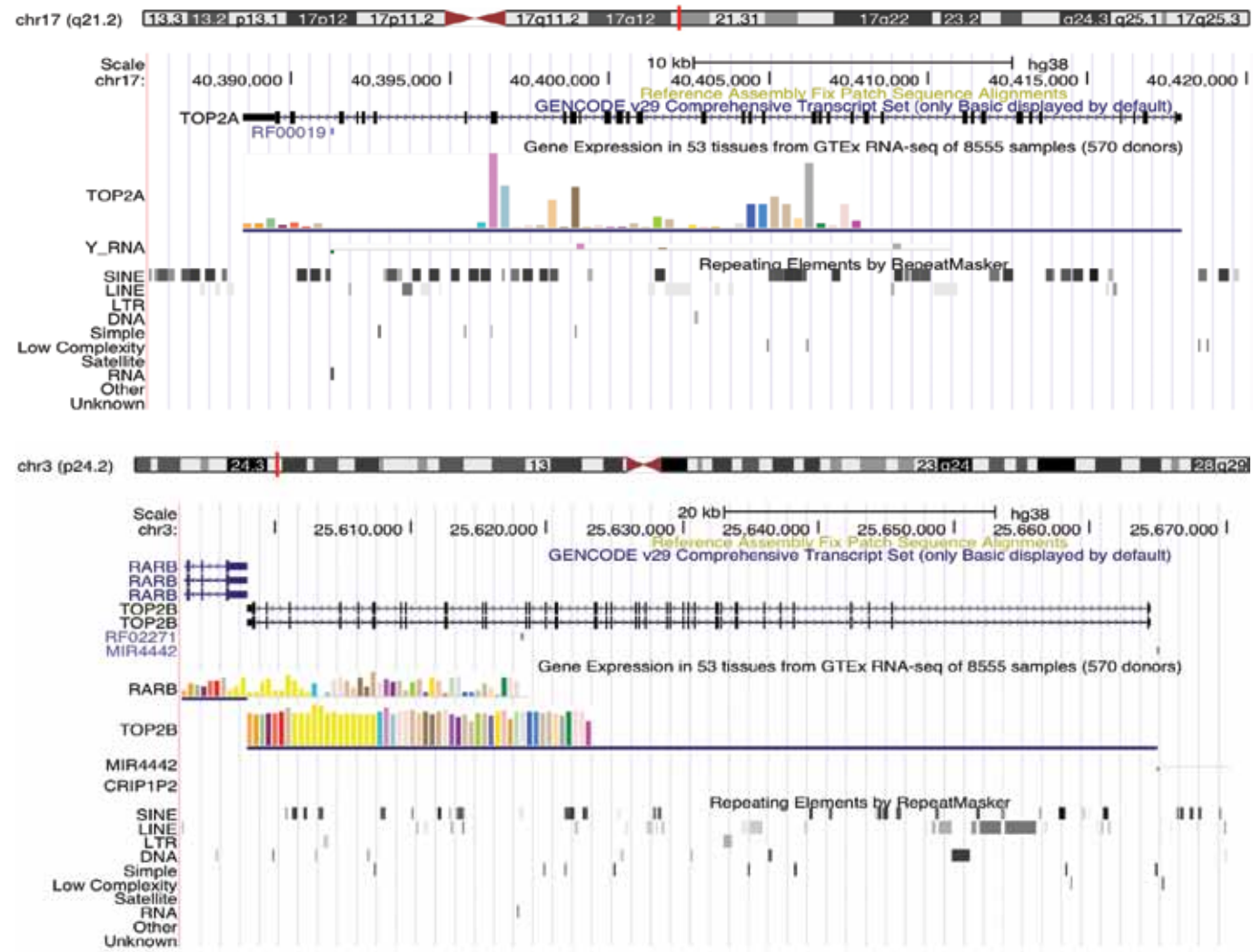


Figure 3. Catalytic Cycle of Type IIA Topoisomerases. 1) The dimeric enzyme binds a helix-helix crossover (one segment in gold, the other in purple). 2) The gate segment of DNA is bent and cleaved. The transport segment is captured by the N-terminal clamp in the presence of ATP. 3) The gate segment ends are separated and the transport segment can cross to the lower portion of the enzyme. This is accompanied by the hydrolysis of one ATP molecule to ADP. 4) The gate segment is ligated and the N-terminal portion of the enzyme rotates. 5) The C-gate opens and releases the transport segment. The second molecule of ATP is hydrolyzed. 6) The C-gate closes and the N-gate opens allowing release of the gate segment of DNA. The enzyme is now reset for another round of catalysis.

Figure 4. Gene Browser Features of the human TOP2A Gene Locus. Data generated online at <http://genome.ucsc.edu/> (Kent, et al., 2002).

Figure 5. Gene Browser Features of the human TOP2B Gene Locus. Data generated online at <http://genome.ucsc.edu/> (Kent, et al., 2002).



gate segment to be ligated (i.e., original bonds reformed and no longer bound to the enzyme). Once the transport segment is released, topoisomerase II can now close the C-gate, release the ADP, and open the N-gate so the gate segment can be released.

This fascinating process involves several highly coordinated and orchestrated events. For example, the ability to cut DNA requires the enzyme to be in a conformation where the DNA gate is closed. This is because each active site requires amino acids from separate halves of the enzyme to be complete. As discussed earlier, topoisomerase II in humans and other eukaryotes is a homodimer—meaning two copies of the same protein. The TOPRIM domain, which coordinates two Mg^{2+} ions from each protein chain interacts with the active site tyrosine from the opposite protein chain to form a functional catalytic site. While the DNA gate is open, or if the protein chains are separated, DNA cleavage and ligation cannot take place. This design feature acts as a fail-safe mechanism that prevents release of the DNA ends from the protein before they are re-attached.

Exploring Two Isoforms of Topoisomerase II

Type II topoisomerases appear to be required for life in living organisms. Even “simple” life forms such as yeast (e.g., *Saccharomyces cerevisiae*) or bacteria (e.g., *Escherichia coli*) encode at least one type II topoisomerase with many organisms encoding two separate enzymes. Humans encode two separate type IIA topoisomerases: topoisomerase II α and topoisomerase II β . These two enzymes are encoded by separate genes on separate chromosomes and controlled by distinct promoters (Nitiss, 2009; Pommier et al., 2016). While topoisomerase II β is widely expressed across a range of tissues (Consortium, 2013), topoisomerase II α expression appears to follow progression of the cell cycle with an increase in S-

phase and mitosis (Nitiss, 2009). Based upon cellular and biochemical evidence, topoisomerase II α is more involved in DNA replication and chromosome segregation, which fits with the observed expression profile (Nitiss, 2009). Topoisomerase II β is more involved in regulation of topology during transcription and for chromatin remodeling (Nitiss, 2009). Recent evidence also indicates a role for topoisomerase II β in domain looping (Uuskula-Reimand et al., 2016).

In mammals, loss of topoisomerase II β at the cellular level can be tolerated (Errington et al., 1999). However, the situation appears to be different at the organismal level. Mice lacking topoisomerase II β die of neural developmental failure (Yang et al., 2000). More recent experiments suggest that this is because of a critical role for topoisomerase II β in regulation of chromatin topology during the process of chromatin remodeling where regions of DNA are “turned on or off” through movement of regulatory components in the DNA. For example, topoisomerase II-mediated DNA strand breaks have been shown in specific cases to be an integral part of regulating gene expression (Bunch et al., 2015; Madabhushi et al., 2015). In contrast, topoisomerase II α is absolutely required at the cellular and organismal levels (Nitiss, 2009). Loss of topoisomerase II α leads to problems with chromosome segregation and cell division (Grue et al., 1998; Akimitsu et al., 2003; Carpenter et al., 2004). During replication, newly synthesized chromosomes, referred to as sister chromatids, become intertwined or catenated. The interlinking of these sister chromatids must be resolved prior to mitosis in order for chromosome segregation to take place properly. Topoisomerase II α is required to carry out this critical function in cells, and topoisomerase II β is unable to fully complement for the loss of the other isoform. Similarly, topoisomerase II α is unable to fully complement for the loss of topoisomerase II β .

What is the reason behind this difference? Why could one isoform not complement for the other? Is it possible that by examining the differences between the proteins we might be able to identify components that are critical for isoform-specific roles in cells? These questions have health relevance as well. Human type II topoisomerases are also cancer drug targets, but the clinically used cancer drugs cannot differentiate between either of the isoforms. As mentioned earlier, some of these drugs have severe risks (i.e., secondary leukemia for etoposide and cardiotoxicity for the anthracyclines) associated with their use, and there is evidence that these adverse events may involve topoisomerase II β . Interestingly, this is the version of the enzyme that is present in all tissues, while growing tissues generally express topoisomerase II α (Drake et al., 1989; Capranico et al., 1992). Therefore, it is of clinical and pharmaceutical interest to be able to develop agents that can selectively target topoisomerase II α (and avoid topoisomerase II β).

The Tale of the Tails

Topoisomerase II α and II β share approximately 65% amino acid identity, though they differ in length by over 90 amino acids (β is longer). Most of the shared amino acid sequence is found in the core domains: ATPase, TOPRIM, DNA binding/cleavage, and C-gate. In these regions, identity rises to >80% (similarity above 90% in some regions). Both the extreme N-terminus and the C-terminus are distinct between the isoforms. For example, the C-terminal domain is very different with only 30% amino acid identity. In evolutionary terms, this portion is considered “variable” compared to the rest of the protein, but it makes up around 25–30% of the protein at roughly 400 amino acids.

Evolutionists believe topoisomerases I and II evolved independently (convergent evolution) multiple times (Forterre et al., 2007; Forterre et al., 2009). In

the specific case of topoisomerase II α and II β , the evolutionary assumption is that these two isoforms originated from a common ancestral topoisomerase II via duplication followed by subsequent divergence (Lang et al., 1998; Sng et al., 1999). The timing of this event is thought to be around the time of the origin of vertebrates since these two isoforms appear to be common to vertebrates, but not typically found in other life forms (Lang et al., 1998). However, the evolutionary mechanism for the divergence of the C-termini is unknown.

Along with collaborators, we found that when comparing the two human isoforms and assuming a common ancestor for them, their sequences appear to be under purifying selection for functional constraint (Deweese et al., 2019). So, it appears that these regions in the two isoforms are different and are under selective pressure to remain that way. From a design perspective, we would argue that this is evidence that these proteins were designed separately (using common modules) to fulfill different functions.

The C-terminus is the least well-understood portion of the enzyme. As noted earlier, no structural data is available for this region in the eukaryotic enzymes, and early research in this area suggested that cells could survive the loss of large segments of this region. However, a more thorough examination is needed.

There are several lines of evidence for complex regulatory roles for the C-terminus in these enzymes. First of all, the evidence from previous studies, mentioned above, regarding the inability of either isoform to fully complement loss of the other even though the catalytic portion of the enzyme is essentially the same. Second, there are a large number of post-translational modifications in this region including phosphorylation, sumoylation, and others (see discussion below). Third, there is evidence for isoform-specific protein-protein inter-

actions with the C-terminus, discussed below (Deweese et al., 2019). Fourth, exchanging this region between the two proteins leads to a change in biochemical and cellular function (Linka et al., 2007). Thus, given our understanding of the similarities and differences between topoisomerase II α and II β , we suggest that the C-terminus is a prime candidate for a complex regulatory role. In other words, why does topoisomerase II β not complement for the loss of topoisomerase II α ? There must be something that one version has that the other is missing, and most of this difference (with some exception at the extreme N-terminus) is found in the C-terminus. Note that the N-terminus also likely plays an important role, but it is only 20–40 amino acids. Therefore, our current focus is on the larger C-terminal domain.

In the following sections, we will explore several pieces of data related to the C-terminus that help provide some insight into the differences between the two isoforms. It has been hypothesized that by examining the C-terminus, we may be able to develop more selective anticancer agents that may reduce adverse events (Murphy et al., 2017).

Surveying Differences between Topoisomerase II α and II β

Genomic Differences

In terms of genomic context, the genes topoisomerase II α (*TOP2A*) and II β (*TOP2B*) are found on different chromosomes. Using the UCSC Genome Browser (<http://genome.ucsc.edu/>), we can gain a better look at the genetic context and components of these genes (Kent et al., 2002). *TOP2A* is on the long arm of Chromosome 17 at chromosome band 17q21.2 (Figure 4), while *TOP2B* is on the short arm of chromosome 3 at chromosome band 3p24.2 (Figure 5). Their exon structures are very similar, but they vary in the intronic regions

with a higher density of SINES (Short Interspersed Nuclear Elements) found in the intronic regions of *TOP2A*. According to the original mapping reports, several exons in the N- and C-terminus differ in their start/end positions (Lang et al., 1998; Sng et al., 1999). In addition, several LINEs (Long Interspersed Nuclear Elements) are found in *TOP2B* that are not found in the other isoform. Interestingly, the genes for both isoforms contain at least one non-coding RNA gene within an intron. The non-protein coding genes are different between the two genes and found inside different introns.

Based upon the gene expression data, clearly *TOP2B* is much more broadly expressed across a range of tissues, while *TOP2A* is much more selectively expressed. Interestingly, 5' of both isoforms are retinoic acid receptor genes. Retinoic acid receptor alpha (*RARA*) is 5' of *TOP2A* while *RARB* is 5' of *TOP2B* (Figure 5).

In reviewing the sequence alignments, it is clear that some regions of the protein are largely shared, as discussed above. However, the extreme N-terminus and the C-terminus are very different between these two isoforms (Figure 6). Several examples of regions of the sequence alignments are shown including snapshots within the largely shared core catalytic regions and in the N- and C-terminus where these two proteins differ so significantly.

Post-Translational Modifications

To examine the post-translational modification (PTM) data, we used the online databases Phosphosite Plus (Hornbeck et al., 2015) and UniProt. Phosphosite Plus enables researchers to examine locations and types of modifications along with the literature and proteomic evidence for those modifications. As seen in Figure 7, both isoforms are known to have many putative sites for PTMs—primarily phosphorylation and ubiquitination. However, much of the evidence in

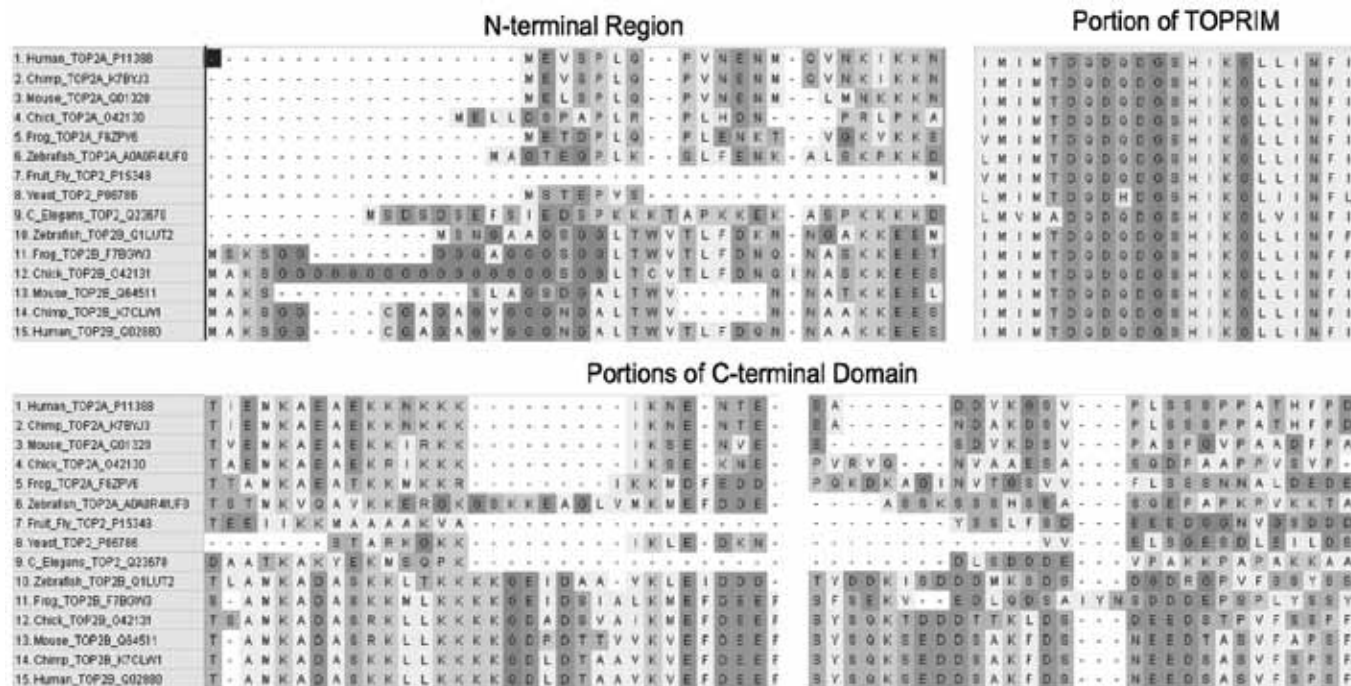


Figure 6. Segments from Sequence Alignments of Type IIA Topoisomerases. Sequences from 15 type IIA topoisomerases are shown. Sequences were retrieved from Uniprot. Selected example regions are shown including the extreme N-terminus, a portion of the TOPRIM domain (metal-ion binding region), and two portions of the C-terminal domain are shown. Alignments were generated using MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets (Kumar, Stecher, and Tamura 2015).

the database for these modifications is from high-throughput proteomics studies. Thus, there have been relatively few research papers published on roles and significance of specific modifications. For example, there is clear evidence for regulatory roles in promoting activity of topoisomerase II α for phosphorylation at Ser-1213 (Wells et al., 1995; Ishida et al., 2001). However, most sites do not have such detailed characterization.

It should be noted that both isoforms have similar numbers of putative modifications, but interestingly, around half of those modifications (91/191 for Top2A) are found in the C-terminal domain (Deweese et al., 2019). Also, when examining both isoforms, a number of the modification sites are not shared between isoforms—especially in the C-terminus (Deweese et al., 2019). Thus,

there are unique modification profiles for both enzymes that may help explain the separate functional regulation. Currently, we are continuing to examine the database evidence for these modifications to characterize the differing profiles between the isoforms.

Protein-Protein Interactions

Protein-protein interactions are also a major factor in the regulation of function in cells. The cellular environment is a very busy, crowded place. The ability of proteins to interact with specificity and cause changes in activity in other proteins is still an amazing thing to consider. These interactions require proteins to have specific sequences, to fold in complex three-dimensional shapes, and to be able to interact in the chemical and pH environment where they operate.

Previously, we showed using The BioGrid database (Oughtred et al., 2019) that topoisomerase II α and II β collectively interact with ~143 proteins and about 34 of these interact with both isoforms (Deweese et al., 2019). More recently, this number has changed to ~153 proteins with only 32 of these showing evidence for interaction with both isoforms. Figures 8 and 9 depict interaction networks generated by The BioGrid database. It should be noted again that this data is primarily from high-throughput studies rather than functional studies. So, little is known about the significance (or lack thereof) for most of these interactions. However, these networks provide a starting point for us in our ongoing analysis of the interactions and modifications of the C-terminal domain of topoisomerase II.

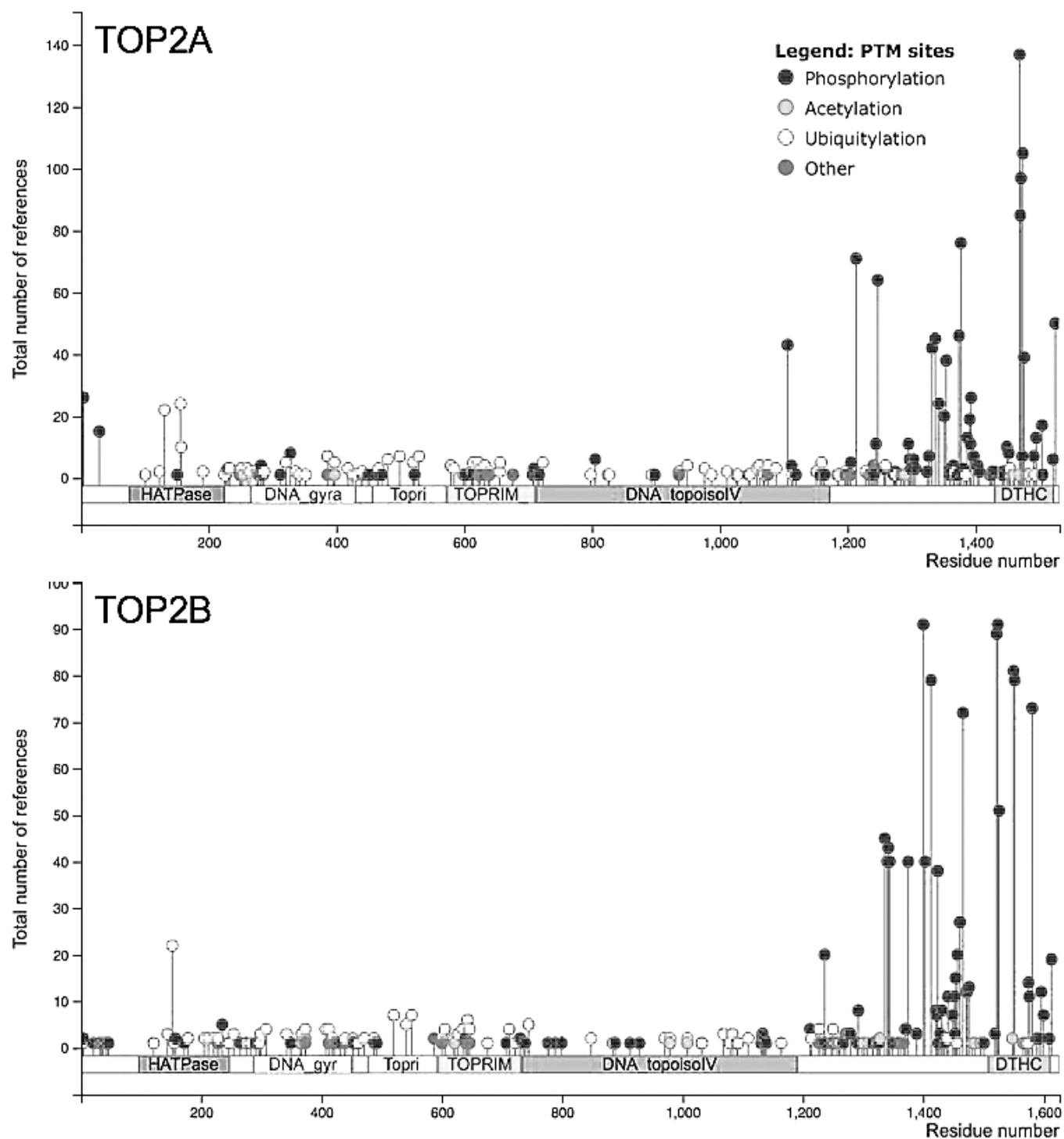


Figure 7. Post-Translational Modifications of Top2A and Top2B from Phosphosite Plus. Modification maps were generated by Phosphosite Plus (phosphosite.org) for *H. sapiens* Top2A (<https://www.phosphosite.org/proteinAction.action?id=2303>) and Top2B (<https://www.phosphosite.org/proteinAction.action?id=5866>). All sites with at least one reference are shown mapped onto the domain structures of the enzymes.

Importantly, it is clear that both isoforms interact with dozens of proteins—with less than half of those proteins shared between the isoforms.

Summary

As discussed above, topoisomerase II α and II β in humans represent two versions of an enzyme that have distinct roles in cells. Even though these enzymes share a catalytic mechanism, they are regulated independently in cells and cannot compensate for the loss of the other isoform. We hypothesize that much of this regulatory function is embedded within the C-terminus of the protein with some regulation also occurring at the N-terminus and possibly at regions within the protein. This model for isoform specific functional regulation of topoisomerase II is not likely unique to this family of proteins, but instead it represents a broader model for protein regulation.

This brings up another important concept: modular protein domains. Several of the domains within topoisomerase II are shared between the isoforms but the regulatory domains appear to be distinct. Could it be that the domains of proteins serve as modules in the original design and thus we see shared protein domains across diverse organisms and protein types? It is also possible that the regulatory domains have taxon specific differences that enable these proteins to operate in the specific cellular context of a given species or genus, for example. This may help explain why some proteins share large portions of information across diverse organisms but also have some regions that are highly specific for a given subset of organisms.

Protein Domains as Modules

Ewert (2018) has argued that protein families can be analyzed statistically using the traditional tree model or using a dependency graph model. In his analysis, he examined the presence or absence

of protein families across a wide range of organisms. His work found that the pattern of the presence and absence of protein families among organisms fit a dependency graph model better than a ancestry tree model (Ewert, 2018). This result was true for each of the protein databases examined. While this does not prove the protein families are sorted in a modular fashion, it is supportive of the possibility. In other words, imagine a designer providing specific families of proteins based upon the needs of specific organisms.

We would like to suggest for it to be considered that this may not be limited to the level of protein families. Many proteins have two or more domains that represent smaller sections of the whole protein but may have a discrete function (e.g., the GHKL ATPase domain of topoisomerase II). What if protein domains are sorted in a modular fashion? How could we know if that was the case? How could we test it?

Interestingly, there is a concept in evolutionary biology called “promiscuous domains” (Basu et al., 2008). These protein domains “show a tendency to occur in diverse domain architectures” (Basu et al., 2008). According to the cited study, these domains seem to appear and come and go along the supposed evolutionary spectrum in a manner not consistent with simple common descent. We suggest that this pattern may fit a “modular” concept better than a tree-like common descent concept, but there is much work that remains to be done in this area.

Further, it is becoming apparent that proteins may also have organism- and species-specific differences that may be finely tuned for a given organism. In other words, there may be high levels of constraint on protein sequences that are organism-specific, which may preclude the ability of these sequences to evolve. This is an interesting area of investigation, and we hope that other scientists will carefully consider that subtle protein

differences among organisms may have implications at the organism level.

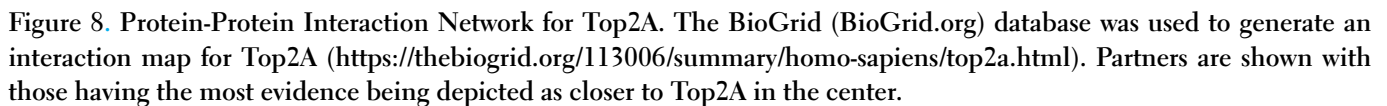
Discussion: Implications and Open Questions

Topoisomerases are fascinating molecular machines responsible for relieving “topological entanglements”—knots and tangles—in the DNA. These enzymes operate by transiently breaking one or both strands of DNA. As drug targets, these enzymes have been exploited in the treatment of cancer. The type II topoisomerases, human topoisomerase II α and II β , are very similar throughout their catalytic regions but differ widely at the N- and C-termini. These regions likely serve regulatory roles for these proteins, and we hypothesize that selective targeting of the C-terminus may enable the generation of selective topoisomerase II drugs that may reduce adverse events in patients.

As mentioned above, topoisomerases are essential to all known forms of life. These enzymes are needed in the simplest of organisms to facilitate the maintenance of DNA. Thus, even the smallest known genomes require topoisomerase activity to facilitate maintenance. The Neo-Darwinian paradigm requires multiple independent yet highly convergent origins for these proteins both among and within the individual topoisomerase families. In other words, the Neo-Darwinian paradigm would require type IIA topoisomerases to originate more than once independently—yet converging on common modules and domains that are widespread (e.g., TOPRIM, GHKL ATPase, etc.).

In fact, evolutionists in the topoisomerase field have acknowledged that topoisomerases present a difficulty for evolutionary explanations:

The phylogenetic distribution of DNA topoisomerases is thus *quite puzzling and clearly does not agree with the classical universal tree of*



Transfer] from a cellular host (e.g. mimivirus Topo IA and IB), in other cases (e.g. Poxvirus Topo IB, T4 Topo IIA) the viral DNA topoisom-

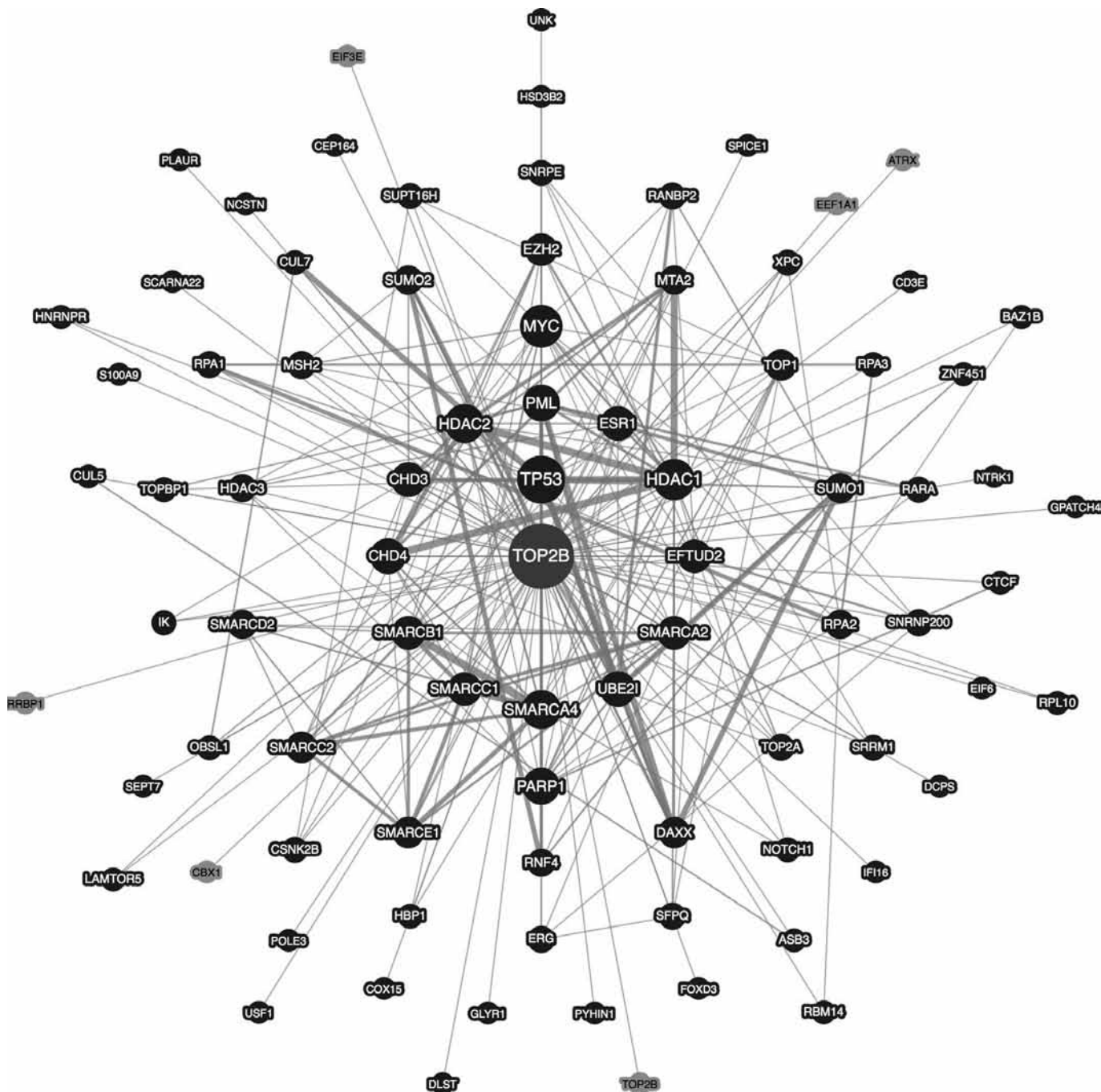


Figure 9. Protein-Protein Interaction Network for Top2B. The BioGrid (BioGrid.org) database was used to generate an interaction map for Top2B (<https://thebiogrid.org/113008/summary/homo-sapiens/top2b.html>). Partners are shown with those having the most evidence being depicted as closer to Top2B in the center.

erases form well-defined subfamilies that are only distantly related to their cellular counterparts. (emp. added) (Forterre et al., 2007)

Ironically, some evolutionists see the large number of diverse topoisomerases as counterintuitive. For example, in a paper on the phylogenomics and origin

of topoisomerases, the authors muse: “An intelligent designer would have probably invented only one ubiquitous Topo I and one ubiquitous Topo II to

facilitate the task of future biochemists. The reality turned out to be quite different, and more interesting.” (Forterre et al., 2009) Aside from the obvious note that these authors have no real clue what “an intelligent designer would have” probably done, their presumption assumes a very reductionist perspective on living systems.

From a design perspective, the diversity of topoisomerase forms makes sense in light of seemingly ever-increasing evidence for specialization of these enzymes. As discussed above, specialization is evident with topoisomerase II α and II β in the fact that each enzyme performs some distinct nuclear functions and cannot fully complement for the loss of the other. This specialization has been acknowledged by others in the topoisomerase field. For example, leading topoisomerase researchers speculate why there are so many topoisomerases:

“We are now beginning to answer that question, and the picture that has emerged is that each of these enzymes has a set of specific functions and that their specialization allows for precise coordination, especially in complicated DNA transactions that are required for replication, transcription and chromosome segregation. Our emerging understanding of chromosome nuclear territories, DNA repair, chromatin-remodeling complexes and super-enhancers, in addition to replication and transcription factories and chromatin looping, underscores the importance of understanding the six vertebrate DNA (and RNA) topoisomerases and integrating that knowledge into our study of genome function.” (Pommier et al., 2016)

Indeed, the topoisomerase field is just beginning to grasp the depth of complexity of these amazing molecular machines. Having six topoisomerases in vertebrates may not seem logical to some reductionists. Using a design perspective, we see living organisms as

engineered systems designed to live and function in diverse environments and contexts. As our understanding of the complexities of the genome increases, the need for more complex regulatory mechanisms becomes apparent. These mechanisms clearly extend to the control of fundamental enzymes involved in DNA metabolism including topoisomerases and a number of other critical enzymes.

It is hard to imagine any one of the topoisomerases developing via an unguided process once—let alone multiple times independently—because they are essential to life, and thus present chicken-egg paradoxes. Evolving topoisomerases incrementally via natural selection would face severe challenges. For example, a partially functional topoisomerase that cuts but cannot ligate (reconnect) the DNA ends would result in permanent strand breaks. If the protein chains of topoisomerase II cannot form homodimers (eukaryotes) or heterotetramers (bacteria), then the enzyme would fail to perform its function since the active site of topoisomerase II requires amino acids from two separate protein chains to function in precise spatial proximity.

Aside from these fundamental issues, there are many other questions that could be raised about the supposed evolution of topoisomerases. What about the communication taking place within the topoisomerase II domains during the stages of the catalytic cycle? What about the complex strand passage mechanism and the coupling of ATP hydrolysis? How could that system develop incrementally? A partially functional topoisomerase II does not solve the major challenges. An objection may be raised by specialists in the field that an enzyme called Spo11 exists, which is able to generate strand breaks (Romanienko et al., 2000). In recent years, this protein has been shown to function in meiotic recombination and has similarity in structure to the subunit

A of topoisomerase VI. It actually forms a heterotetramer with a second protein, Top6BL (Robert et al., 2016; Vrielynck et al., 2016). This highly specialized role for Spo11/Top6BL highlights the increasing specificity of function among these enzymes. Thus, Spo11 does not answer any of the above questions since it also serves a critical, highly-specialized cellular role.

These questions bring up a final thought: how do topoisomerases get to where they are needed and “know” when and where to act? This is a complex question and one that will likely be solved in the next few years. We hypothesize that localization is a function of the C-terminus of the protein and likely involves protein-protein interactions, post-translational modifications, and chromatin-topoisomerase interactions.

Conclusion

From a design perspective, these enzymes have been present since the beginning and are uniquely suited to increasingly specialized roles. The more we learn of the localization, regulation, and specialization of topoisomerases, the more complex and nuanced the picture becomes. Thus, we argue that these amazing “molecular scissors” are precisely what Paul spoke of in Romans 1:20—the “things that have been made” that enable us to see His everlasting power and divinity.

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Deep Time Philosophy Impacts Radiocarbon Measurements

Vernon R. Cupps and Brian Thomas*

Abstract

The late R.E. Taylor et al. have written technical materials that disparage results showing that C-14 persists in carbonaceous materials dated by secular scientists at millions of years old. Given the relatively short theoretical shelf life of C-14 of no more than 100,000 years, the presence of C-14 in such samples challenges standard age assignments. Taylor attempts to refute these C-14 results by belittling them and claiming that those who present them misunderstand the background requirements of Accelerator Mass Spectrometer (AMS) procedures during the initial phases of carbon dating. In response, we first review the required analytical and logical steps used for standard carbon dating. This allows us to pinpoint the elements necessary to determine the presence or absence of radiocarbon in a given sample, for example a Cretaceous fossil. Finally, we critique some of Taylor's arguments. We find that his attempted refutations fail due to a lack of supporting data, the presence of contrary data, the begging the question epithet, and belittling in place of substance.

Introduction

The late R.E. (Erv) Taylor and two University of California colleagues presented an argument in *Radiocarbon* (Taylor, Southon, and Santos, 2018) that those who point to radiocarbon in Cretaceous materials simply misunderstand the significance of Accelerator Mass Spectrometer (AMS) background

^{14}C measurements. They do not refer to such individuals as biblical creationists, but their rhetoric is aimed squarely at conclusions published in creation literature, most notably results from the Radioisotopes and the Age of The Earth (RATE) project. The authors' apparent intent is to discredit those and other findings which reveal that organic

materials dated at hundreds of millions of years still contain measureable ^{14}C . Their motivation is easy to surmise: If genuine and widespread, this anomalous radiocarbon implies that the current dating methodology used by secular science is in serious error. The Taylor and Bar-Yosef (2014) textbook on radiocarbon dating also presents a rather unflattering rant against YEC's work with ^{14}C . The purpose of this paper is to critique the Taylor, Southon, and Santos (2018) assault on radiocarbon research published by creation researchers.

We can quickly dismiss comments that merely disparage the creationist

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outlook in that such remarks have no scientific substance. So the main issue to address from a scientific point of view is the validity of Taylor's refutations of findings that show ^{14}C throughout earth's rock layers, including material from basement Archean rocks (Taylor and Southon, 2007).

Radiocarbon Basics

We first provide a review of the basic principles used in radiocarbon dating to build a context for an evaluation of the arguments presented in Taylor, Southon, and Santos (2018). In the 1940s, chemist Willard Libby developed a method for dating organic materials using the decay of a radioisotope of carbon, i.e., carbon 14 (^{14}C , C-14, or radiocarbon) as its foundation. The method assumes that ^{14}C has been generated in earth's atmosphere for millions of years by the nuclear reaction $^{14}\text{N}(n,p)^{14}\text{C}$ in the upper atmosphere. This ^{14}C forms CO_2 that mixes with the lower atmosphere where living organisms incorporate it through photosynthesis or ingestion and metabolism. Carbon 14 decays back to ^{14}N via beta decay, i.e., $^{14}\text{C} \rightarrow ^{14}\text{N} + e^- + \bar{\nu}$. The beta particle (e^-) can then be counted using a beta-counting device such as a liquid scintillation counter and the rate of beta counts per gram of carbon converted into a concentration of ^{14}C .

Today, the AMS method is used almost exclusively to measure the amount of ^{14}C in a sample. Rather than counting beta particles over a certain time interval, the AMS method counts the actual numbers of ^{14}C , ^{13}C , and ^{12}C atoms and determines their ratios. Compared to the beta-counting method, AMS systems can use smaller samples, have lower counting times and much higher sensitivity. Thus, AMS has become the preferred method of ^{14}C dating. Initially it was thought that AMS system's higher sensitivity would enable older ages to be obtained (Schmidt, F.H. et.al. 1987),

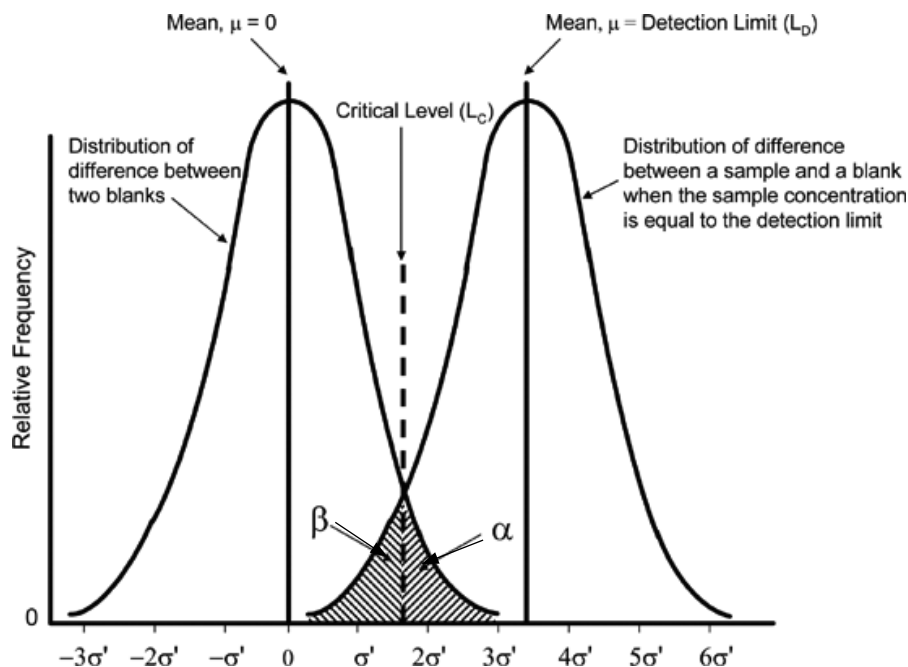


Figure 1. A schematic diagram for assessing the statistical reliability of measurements involving both a background (left-hand curve) and a sample (right-hand curve).

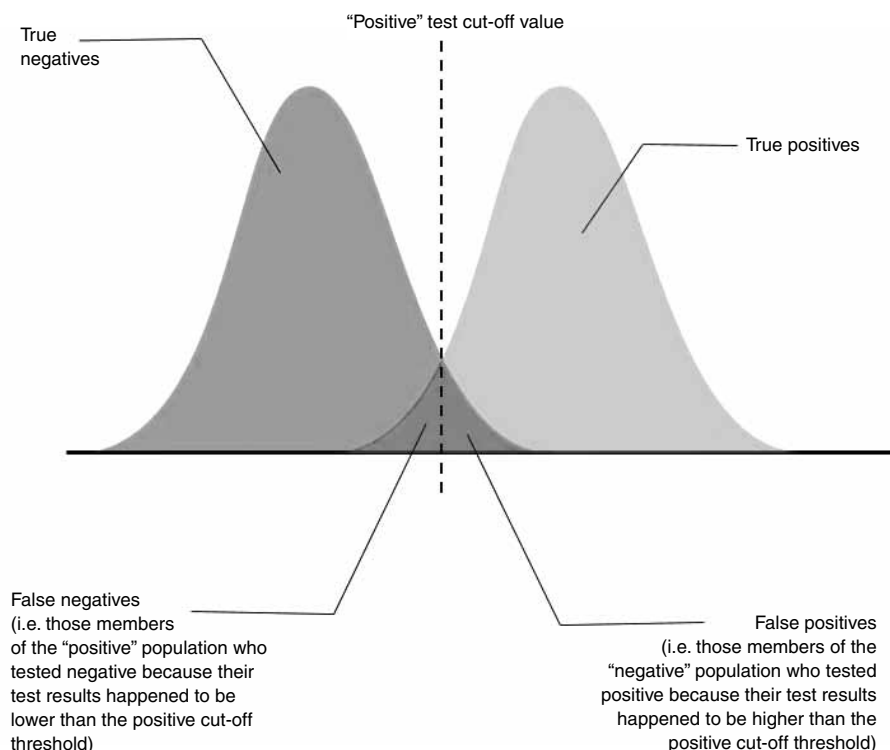


Figure 2. The limit of detection (L_D or sometimes $CC\beta$) is the lowest concentration of ^{14}C that can be detected at a specified level of confidence. $L_D \approx (\mu_{\text{blank}} + 3 \times \sigma_{\text{blank}})$ for a 99.7% confidence that the measurand (^{14}C in this case) is present.

but problems with background measurements have dimmed those expectations.

The sensitivity of both methods is limited by what is generally referred to as “background.” In the case of the beta counting method, cosmic rays cause spurious counts that are not a consequence of ^{14}C decay. In samples with very small ^{14}C concentrations, this cosmic ray background can give a comparable number of counts as actual beta particles from ^{14}C decay. Therefore, proper interpretation of radiocarbon measurements requires an accurate assessment of background levels.

In the case of the AMS method, there are several potential sources of ^{14}C . Taylor, Southon, and Santos. (2018) point out that these include both instrument based sources and sample based sources. The former arise in the hardware itself, such as electronics noise and stray ^{14}C atoms from previous runs on surfaces in the sample ionization chamber. The latter includes contributions from the several steps in laboratory sample preparation, including sample pretreatment to remove surficial contamination, the conversion of the pretreated sample to CO_2 via combustion and acid dissolution, the reduction of the CO_2 to graphite, and the transfer of the graphite to the AMS sample holder. Generally speaking, AMS labs monitor each of these sources of spurious ^{14}C carefully and keep their levels extremely low.

The general equation commonly used to convert the ratio of daughter to parent isotopes of a given (typically igneous rock) rock sample into an age does not apply to ^{14}C dating because the daughter nucleus, ^{14}N , is extremely mobile and abundant in earth environments. So, in order to date organic matter or carbonaceous artifacts using the decay of ^{14}C as a clock, a more complicated equation must be used. If we can measure the current amount of ^{14}C (i.e., the $^{14}\text{C}/^{12}\text{C}$ ratio) in a given sample and if we also assume an accurate estimate of the amount of the $^{14}\text{C}/^{12}\text{C}$ that was

in the sample originally, then we can calculate a carbon age of the sample using the equation:

$$\frac{1}{\lambda} \ln \frac{N_0}{N_p} = t_a \quad (1)$$

where N_p is the present amount of ^{14}C (N = nuclei) in the sample, N_0 is the amount of ^{14}C originally in the sample and assumed to be proportional to the $^{14}\text{C}/^{12}\text{C}$ of the international radiocarbon standard, and λ is the decay constant for ^{14}C . The amount of ^{14}C currently in any given sample can in principle be measured either by beta particle counting spectroscopy or an AMS system. However, problems begin to emerge when one attempts to estimate N_0 for a given sample. The amount of ^{14}C accumulated in any living organism during the photosynthesis process (for plants) or the metabolism of food (for animals) and remaining when it dies (N_0) depends on time and environment. For example, increased use of fossil fuels with the advent of the industrial revolution in the eighteenth century began diluting the concentration of ^{14}C in the atmosphere with ^{12}C . This lowered the prior normal ratio of ^{14}C to ^{12}C in terrestrial living organisms. Similarly, nuclear testing that began in 1945 created non-cosmogenic ^{14}C that increased the ^{14}C to ^{12}C ratio in the atmosphere as well as in living organisms. These variables illustrate the challenge of assuming an accurate estimate for N_0 of a long-dead organism, which assumption becomes increasingly tenuous with possibly more unknown variables in increasingly older samples.

Because of difficulties in determining N_0 , values for ^{14}C content are generally reported as either the corrected percent modern carbon (pMC*) [pMC* $\equiv$ (sample-background)/(modern-background)] $\times 100\%$ or the uncorrected percent modern carbon (pMC) [pMC $\equiv$ (sample/modern)] $\times 100\%$. The “modern” ^{14}C is the 1850 ^{14}C value (N_0) normalized to 1950.

Evaluating Measurements

Measurement science requires an evaluation of two basic parameters in the measuring device: the sample background and the sample itself. The experimenter needs an accurate evaluation of the ^{14}C background in order to establish an intrinsic ^{14}C concentration for an organic sample. Likewise, workers must assess whether the background measurements rise sufficiently above the detection limits of the measuring apparatus to achieve statistical significance. Figures 1 and 2 schematically illustrate this concept. Proper reporting of ^{14}C measurement results should include error bars on both the sample and the sample blank. These error bars ought to include systematic as well as statistical errors. The mean values for the sample blank and the sample then serve as the apex or height of Gaussian curves describing each, while the width of each curve (σ) is given by the error bars of the measurement. Once constructed, these curves permit statistical evaluation of sample measurements. A 95% (2 sigma) or 99.7% (3 sigma) confidence level means that the sample measurement area is 95% or 99.7% beyond the area defined by the sample blank. The limit of detection (L_D) for a given measurement equals the sample blank mean value + 1.645 $\times$ the sample blank error (σ_b), or mathematically, $S_b + 1.645 \times \sigma_b$. For a 99.7 % confidence in the limit of detection, 3 is substituted for 1.645 in the above equation. This is also colloquially referred to as a 3 sigma confidence level. In our experience, most of the basic measurements of isotope ratios in ^{14}C dating do not include potential systematic error analyses or a statistical evaluation of their data.

Real Radiocarbon Misunderstandings

The presence or absence of intrinsic ^{14}C can be reasonably ascertained from measurements once the ^{14}C background

has been accurately measured. Note that thus far no attempt to estimate the age of a sample has been made or is even necessary to draw a reasonable conclusion about the presence or absence of residual (intrinsic) ^{14}C in that sample. However, Taylor, Southon, and Santos (2018) start their argument by defining all ^{14}C sample measurements to fall into either infinite age or finite age categories. They thereby bias the discussion in favor of the deep time paradigm so popular among secular scientists. Uniformitarians describe a sample of *infinite age* as one “for which it can be reasonably assumed,” with confidence, that all intrinsic or residual ^{14}C that it originally contained has long decayed away (Taylor, Southon, and Santos, 2018)—for example Pennsylvanian System coals with assigned ages of hundreds of millions of years. They then use this deep-time assumption, not measurements or data, to conclude that any ^{14}C detected in an infinite age sample must be due to contamination or improper background determination.

Taylor, Southon, and Santos (2018) assert that those who interpret ^{14}C measured in infinite age samples as intrinsic to the sample rather than implicating contamination or improper background determinations are knowledge deficient in one or more of these four areas:

- i. The definition and implications of “backgrounds” and “sample blanks” employed in AMS-based measurements,
- ii. understanding the difference between finite and infinite ^{14}C age determinations,
- iii. the distinction between “machine-based backgrounds” and “sample-based backgrounds” in creating net background values unique for each AMS system measuring natural ^{14}C and,
- iv. the effects of trace amounts of modern or near modern contamination on measured ^{14}C values when dealing with infinite age samples.

We now address each of these so-called deficiencies:

i) Ignorance of “backgrounds” and “sample blanks”

In all machine-based measurements, the total background is a combination of that which originates from the machine and the environment plus that which originates from a sample blank. This is standard throughout many industries and is the reason why sample blanks must be chosen wisely. Ideally, if one is going to measure ^{14}C in a given organic sample then a sample blank identical to the actual sample in every way but devoid of ^{14}C should be chosen. Organic samples would fit that profile if they really were millions of years in age. If the sample blanks are more recent than deep time proponents assert, then one should choose a sample blank as close to or below the AMS sensitivity limits as possible. Thus, if the sample blanks are not as old as Taylor and colleagues insist, then it is their knowledge that is deficient, rather than that of those they accuse of ignorance. Simply put, if sample blanks can be found or manufactured with a lower $^{14}\text{C}/^{12}\text{C}$ ratio than the supposed infinite age sample blanks, it suggests that those supposed infinite age samples are not of infinite age after all.

ii) Ignorance of finite and infinite ^{14}C ages

This supposed deficiency begs the question at hand, i.e., AMS background ^{14}C measurements. The concepts of finite and infinite time ^{14}C age determinations are arbitrary definitions coined by the secular community. They have nothing to do with the proper measurement of ^{14}C in terrestrial samples of organic materials, and even less to do with determining the presence or absence of radiocarbon in a sample. The more relevant question concerns whether the “infinite age” samples are actually infinitely old in carbon years. This question should be settled by data, not assumption.

iii) Ignorance of “machine-based backgrounds” versus “sample-based backgrounds”

Generally, there is no distinction between “machine-based backgrounds” and “sample-based backgrounds” in creating a net background to subtract from the ^{14}C sample if the measurement was done according to normal protocols. The distinction only exists for the experimenter who is attempting to obtain an accurate evaluation of net background contributions. The primary contributors to the net background are most often sample-based. Sample-based backgrounds are the more appropriate for use in the formula given above for pMC*. It is fair to question if variations in backgrounds from the machine and the sample blank can impact measurement of a sample’s residual (intrinsic) ^{14}C content. Experimental data is only as reliable as its repeatable experimental methodology. Perhaps the best evidence of this is that samples that were measured, processed in the prescribed way, and re-measured can have higher $^{14}\text{C}/\text{C}$ ratios after reprocessing. For example, Arnold et al. (1987) took graphite, which had a measured $^{14}\text{C}/\text{C}$ ratio of 0.089 ± 0.017 pMC when placed on a sample holder, oxidized it to CO_2 , reduced it back to elemental carbon, and put that on a sample holder. That same graphite sample now measured a higher $^{14}\text{C}/\text{C}$ ratio of 0.34 ± 0.11 pMC. Clearly, the added radiocarbon came from the laboratory environment. A similar experiment by Van Der Borg et al. (1997) observed a graphite sample going from 0.04 ± 0.02 pMC before processing to 0.18 pMC after processing. These two experiments suggest that in equivalent laboratories, laboratory processing can add 0.14 to 0.25 pMC which is not negligible when evaluating samples with small residual radiocarbon amounts, such as coal.

Unfortunately, this kind of experiment is not often recorded in the literature, and sometimes one has to use less

direct methods to determine how much laboratory contamination is routine. Middleton et al. (1989) measured CO_2 directly, produced by dolomite, at 0.01 pMC when handled with extreme care and 0.5 pMC when handled with less care. Schmidt et al. (1987) reported several graphite samples that varied in their $^{14}\text{C}/\text{C}$ ratio depending on the care used in lab preparation. They even noted a finite “age” (0.05 pMC) for ^{12}C from a Faraday cup in their AMS machine, which was effectively functioning as a mass spectrometer to separate ^{12}C from ^{14}C . Even these trace contributions, when compared with the relatively higher ratios of supposedly ancient samples, argues quite strongly for the existence of residual (intrinsic) radiocarbon in so-called “infinite age” samples. Such radiocarbon content is incompatible with age assignments greater than 100,000 years. This is because a properly done measurement subtracts the total background from the measured sample. A detailed discussion of AMS backgrounds used in ^{14}C measurements can be found in Baumgardner (2005) and Baumgardner et al. (2003). In these references a background standard of 0.077 ± 0.005 percent modern carbon (pMC) constructed from purified natural gas CO_2 was used in determining the ^{14}C content of coal samples that should be radiocarbon dead. The pMC unit defines the N_0 or original ^{14}C as 95% of the radiocarbon concentration (in AD 1950) of NBS Oxalic Acid I (SRM 4990B or equivalent) normalized to $\delta^{13}\text{C}_{\text{VPDB}} = -19$ per mil. (Stenström, et al., 2011.)

iv) Ignorance of trace amounts of modern or nearly modern contamination sources

Finally, uniformitarians should bear the burden of proof in demonstrating that (and showing how) modern radiocarbon infiltrated their sample blanks enough to raise the radiocarbon concentration so far above the theoretical sensitivity limits of a given AMS system. The

Table 1. Published radiocarbon measurements of coal-sourced carbon.

Author	Date	Material	pMC
Beukens et al.	1982	acetylene*	0.142 ± 0.028
Beukens	1983	acetylene	0.014 ± 0.010
Farwell et al.	1984	cracked coal tar	0.044
Gillespie and Hedges	1984	cracked petroleum	0.1 ± 0.05
Terrasi et al.	1990	coke	0.3

* Probably made from calcium oxide and coal

question is whether “the effects of trace amounts of modern or near modern contamination on measured ^{14}C values when dealing with infinite age samples” has been taken into account (Taylor, Southon, and Santos, 2018). Taylor and coauthors mention the problem but fail to quantify it.

In principle, adding to an infinite age sample enough modern carbon (contamination) to raise the final concentration to one part modern carbon in 1,000 parts total carbon will leave a final ^{14}C concentration of exactly 0.1 pMC. It is really that straight forward. Mixing half and half would give 50 pMC. Replacing 100% of a carbon dead sample with modern carbon will give 100 pMC. If we repeat the 1/1000 exercise with 1940 carbon at 95 pMC, we get 0.095 pMC, and using actual modern carbon at approximately 110 pMC, would yield 0.11 pMC. This means that if we wish to explain dinosaur remains having a $^{14}\text{C}/\text{C}$ ratio of 3% (not unusual), we must believe that 3% of the sample has been replaced with modern carbon (or alternatively 3.1% of modern carbon has been added to the sample). Given the relatively short half-life of radiocarbon, this would require that the replacement occur within the last few years. If it occurred 5,730 years ago (the ^{14}C half-life), the corresponding numbers are 6% and 6.4%. This interesting proposal implies that the material is constantly churning new carbon into the sample. The supposed contaminant could be restricted

to a defined portion of the sample, or over millions of years should replace the entire sample.

Alternatively, the supposed replacement scenario would have been limited to the last few thousand years—not a terribly uniformitarian idea. In other words, the assertion of modern contamination to explain small amounts of radiocarbon in fossils may appear reasonable until one starts to put numbers to it. At present, their reason for concluding contamination in sample blanks is merely circular. Since the sample blank is 240 million years old, it has no original radiocarbon left. But radiocarbon is detected. Therefore, the detected radiocarbon must derive from some source other than the millions-of-years-old sample. Remove the uniformitarian bias and we have samples with intrinsic radiocarbon. This would erase the need to define (rather than measure) any sample as carbon dead or as having infinite age.

Since processing can introduce measurable contamination, it would be prudent to use caution if comparing graphite, which needs no processing, with coal, which typically is processed by oxidation and then reduction in preparation for radiocarbon measurements. One way to directly compare graphite to coal is to heat the coal and measure it directly. Unfortunately, there is a dearth of reported experiments using this procedure. Table 1 summarizes the few related examples we could find in the literature.

Another way to compare graphite with coal would involve processing the graphite like one would process the coal. Again, such experiments are rare; Arnold et al. (1987) and Van der Borg, et al. (1997) are two of the only three experiments we could find. The third experiment is noted below.

One can get around this problem of contamination via processing (mostly the combustion step) by showing that a particular laboratory has a very low background regardless of sample type. For example, the laboratory that used to be in Toronto had consistent backgrounds of 0.07 to 0.08 pMC for reduced samples. Another laboratory with consistently low backgrounds is Australian National University (ANU), reported by Bird et al. (1999), who describe an elaborate procedure that enabled untreated “Ceylon graphite” (Precambrian with Cambrian metamorphosis) background measurements to reach down to 0.046 pMC, (average of 9 samples). Graphite cycled through their process measured 0.04 pMC (average of 4 samples), meaning that the procedure added virtually no contaminating radiocarbon.

This level of competence cannot be attributed to other laboratories unless they also test themselves, refuting claims about all measured carbon being residual carbon. As noted above, somewhere around 0.1 to 0.3 pMC, or perhaps more, can be added to samples simply by oxidizing and then reducing it in a less optimal laboratory. Two laboratories added only 0.00 to 0.077 pMC during processing—levels that leave the RATE group data intact, as shown below. Possibly, Taylor, Southon, and Santos (2018) are referring to the ambiguity of discerning between $^{14}\text{N}^-$ and $^{14}\text{C}^-$ in the AMS ^{14}C detector. However, the authors themselves argue that negative ^{14}N ions have such a short lifetime ($< a$ few microseconds) that they do not make it to the ^{14}C detector. Even if they did, they should be included as the average machine background which already

gets subtracted from the unknown ^{14}C sample signal.

Let’s now look at those sources of contamination that Taylor, Southon, and Santos (2018) list in their Table 3. Rather than theoretically discounting them, let’s ask how workers could detect those sources of error. If the machine runs without a sample, one could detect target/cathode contamination and all other instrument-based sources. Specially cleaned (or naturally clean) sample runs could detect manipulation and storage sources, and possibly contamination during sample pretreatment. And if one runs a sample that was oxidized and then reduced, then combustion and graphitization sample preparation sources could be measured as well. So with the proper controls, one could empirically show that the contamination can be reduced to manageable levels. And manageable levels, not proof that all ^{14}C is residual, are all one needs to determine if a sample has residual radiocarbon or not.

ANU was at one time the best laboratory for measuring very low levels of ^{14}C , but even the lab that the RATE group used was very good. It is certainly possible to reduce laboratory contamination to a negligible level.

In summary, the argument that backgrounds are not properly understood as the reason for measureable ^{14}C in samples with millions or even billions of years’ age assignments relies on the assumption of deep time, not on any measurement. Taylor and colleague’s (2018) four supposed deficiencies really do not deal with the actual measurement of low levels of ^{14}C in samples or sample blanks. Rather, they focus on dating results from models that, for them, trump measurements. Conclusions drawn from observational evidence should outweigh conclusions drawn from models. Taylor, Southon and Santos (2018) fail to scientifically support their contention that the detection of radiocarbon in fossils arises from misunderstanding background measurements.

An Argumentative Diversion and a Logical Fallacy

R. Ervin Taylor was a leader in his field, and certainly deserves respect and appreciation for his involvement in the establishment of AMS systems for use in radiocarbon dating and for his expertise in working with bone in particular. However, poor reasoning including an argumentative diversion and a logical fallacy lurk near the core of his objection to measurable radiocarbon in supposedly carbon dead samples.

His *Radiocarbon* paper (2018) appears to use a shotgun argument. This refers to a disputation tactic wherein one fires so many reasons for their position that the opponent cannot respond to them all. Only one of the 16 potential sources of supposed contamination listed in Table 3 by Taylor, Southon, and Santos (2018) reflects radiocarbon endogenous (intrinsic) to the sample blank. We have no disagreement that radiocarbon could theoretically arise from any of his listed sources. However, what experimental evidence suggests that the amounts of radiocarbon detected in sample blank measurements could, let alone should, arise from any or a combination of these sources rather than arising from the blank itself? Taylor argues that since this is only one possibility out of 16, the odds favor the other 15. This shotgun argument incorrectly weights each potential source equally. The potential for ^{14}C to enter the system from such sources as the instrument components or electronic noise in the detector may be too small to account for the levels of ^{14}C routinely measured in supposedly dead carbon blanks, as shown by studies that Taylor, Southon, and Santos (2018) cite. Is their shotgun approach an attempt to mask the burden of proof they bear to demonstrate (not just assert) that the 15 potential sources from which they want extra ^{14}C to arise are actually capable of consistently supplying the levels of ^{14}C routinely detected in sample blanks?

In addition, the study authors rely on a logical fallacy called the begging the question epithet. This occurs when one concludes that which one assumed in the first place. In this case, Taylor, Southon and Santos (2018) argue in a circle when they refer to "...samples reasonably assumed to contain no measureable cosmogenic ^{14}C ." What makes this assumption so reasonable? They explain, "In ^{14}C studies, a sample used for background measurements would be an organic of sufficient geological or paleontological age so that it can be reasonably assumed that, given the ^{14}C half-life of ~ 5700 years, all of that sample's original ^{14}C content should have been reduced to zero." This reveals faith in geological and paleontological age assignments despite deep problems with the methods its practitioners use, including discordant "ages," old "ages" for young samples, evidence of open system behavior such as accelerated nuclear decay and hydrothermal transport of parent and daughter components, and circularity. Thus, they employ circularity when they conclude that sample blanks are carbon dead on the basis of the assumption that the blanks must be carbon dead. Ironically, radiocarbon levels in their own geologically sourced radiocarbon sample blanks should challenge the very geological age assignments that they trust so implicitly.

Examples, Limits, and Backgrounds

We now take a closer look at some actual ^{14}C measurements that Taylor and colleagues call into question. These examples illustrate the principles discussed above. Multiple references (Baumgardner, et.al., 2003, Baumgardner, 2005, Snelling, (1997, 1998, 1999, 2000a, 2000b), and Giam, 2001) attest to the widespread presence of measureable radiocarbon in Phanerozoic strata. In the late 1990s Andrew Snelling (1997, 1998, 1999, 2000a, or 2000b), relying on reputable AMS laboratories, found a range

of 7.58 ± 1.11 percent modern carbon (pMC) for a lower Jurassic sample, and 0.38 ± 0.04 pMC for a middle Tertiary sample. Table 5 of Taylor, Southon, and Santos (2018) show possible "infinite" carbon sample blanks. These data suggest a detection limit of 0.15 pMC for processed geological graphite, 0.12 pMC for unprocessed geological graphite, 0.17 pMC for processed coal, 0.08 pMC for unprocessed diamond, and 0.18 pMC for processed diamond to a 99.7% confidence level. The pMC notation represents the proportion of radiocarbon in a sample compared to that present in 1950—the pre-nuclear testing era and equal to "0 years before present (BP)" by convention. $\text{pMC} = 100 (0.5^{\text{C-yr}/5568})$, where 5568 is Libby's original half-life still used by convention. Thus, 1,090 radiocarbon years BP correspond to a pMC of ~ 87.8 , and 41,010 carbon years BP correspond to a pMC of ~ 1.53 . If Snelling's sample results were background subtracted and we use the 0.17 detection limit from Taylor's Table 5 (Taylor, et. al. 2018), then 7.58 ± 1.11 pMC means that there is a 99.7% probability that the Jurassic sample's intrinsic pMC value is greater than 0.17 pMC and a 67% chance it lies between 5.36 and 9.80. Likewise, there is a 99.7% probability that the middle Tertiary sample's intrinsic pMC value is greater than 0.17, and a 67% chance it lies between 0.30 and 0.46 pMC.

Current AMS technology can reliably measure a ratio of 10^{-16} (0.01 pMC) and in some cases down to 0.001 pMC. This would be the sensitivity of the measurement but not the limit of detection (L_D) given above. Therefore, to a high degree of confidence, radiocarbon exists in these samples (which should be radiocarbon dead according to secular time scales). One can reasonably conclude that both the above measurements are well above the detection limits for a carefully operated AMS system.

What about the claim of these measurements, plus so many others taken

from samples of supposedly infinite age, simply being background? Background is defined as the residual machine background plus the sample blank. Precambrian limestone environments typically produce ^{14}C values of 0.05 pMC (Baumgardner, 2005, p. 604), well above the sensitivity limits of AMS systems. This is a typical problem encountered in measuring very low levels of nearly ubiquitous radioisotopes, such as ^3H and ^{14}C , in the environment. Therefore, it is incumbent on the experimenter to maintain as clean a machine as possible and to choose the sample blank to provide the lowest possible background. Perhaps a better choice than those currently in use for a sample blank would be one of the diamonds which Taylor and Southon (2007) analyzed to monitor AMS backgrounds; specifically, sample numbers UCIAMS-9639 and UCIAMS 9640.

Since any reliable measurement must subtract known background contributors, it is reasonable to assume measurements such as those reported by Snelling, RATE, and others represent radiocarbon above the background. In fact, the results for ten RATE (Baumgardner, 2005, p. 605 and 608) coal samples each had a "standard background" of 0.077 ± 0.005 pMC subtracted from the final quoted pMC value. For this background the 99.7 % detection limit would be approximately 0.092 pMC. Thus, eight of ten measurements are still 2 to 3 times the detection limits of those AMS measurements at a 99.7% confidence level. Clearly, intrinsic ^{14}C exists in these samples. Their burial deep below ground, and thus far from solar radiation, renders contamination highly improbable (Baumgardner, 2005, p 614–615, Cupps, 2017).

Radiocarbon in Diamonds

This raises the question: Does ^{14}C exist in detectable levels for all terrestrial carbon, and if so at what levels? Natural

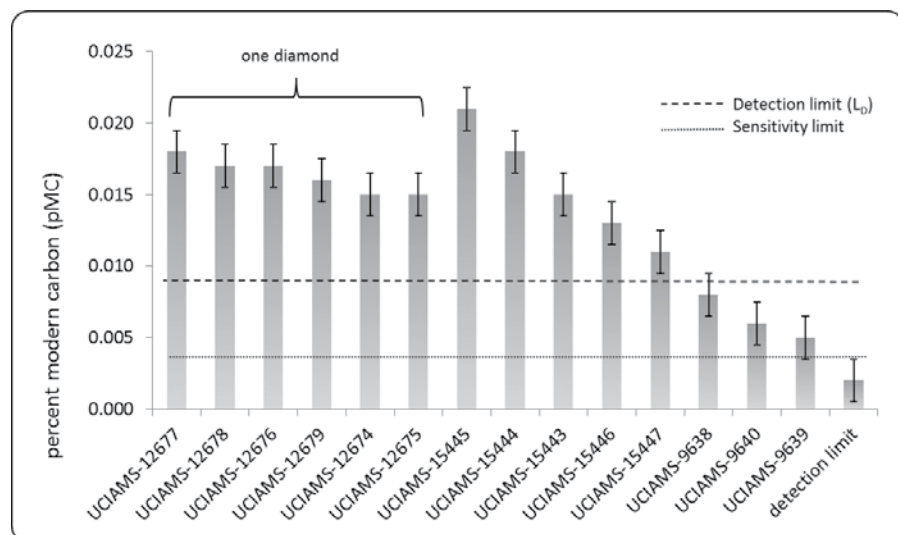


Figure 3. Background values from Taylor and Southon (2007) were used to estimate a L_D of approximately 0.8 pMC at 99.7% confidence (dashed line). Dotted line represents an AMS sensitivity limit estimate. The most parsimonious interpretation of pMC levels above both lines is that from six to ten of their ten diamonds contained intrinsic radiocarbon.

diamonds present one potential test of this hypothesis. They are formed under very high pressures only naturally realizable at depths of greater than 100 km inside the earth. They are also extremely resistant to contamination via chemical interaction with their environment. Uniformitarians believe that natural diamonds found near the earth's surface were formed 1 to 3 billion years ago in the earth's upper mantle and brought to the surface through kimberlite pipes. They would thus assert that these diamonds have been locked away from contact with the earth's atmosphere since early in earth's history. If ^{14}C with its relatively short half-life exists in measurable amounts in such natural diamonds, then it presents a significant challenge to deep time advocates.

We therefore plotted (Fig. 3) the carbon ages for diamonds using data reported by Taylor and Southon (2007) along with a typical AMS detection limit (L_D) from Table 5 in Taylor, Southon, and Santos (2018) according to the

following steps. First, each reported "Fraction modern" (fm) value was converted to uncalibrated carbon years using $[-8033 \times \ln(\text{fm})]$. Each resulting carbon age was converted back to pMC using $[100 \times 0.5^{(\text{C-ys}/5568)}]$, with 5568 being the less accurate but conventionally used Libby half-life for radiocarbon. Reading left to right, the first six bars of Fig. 3 show six replicate measurements from one diamond. The next eight bars show single measurements from eight separate diamonds. The dotted line shows a typical theoretical sensitivity limit for modern AMS instruments of 0.002 and the dashed line an approximate limit of detection (L_D) at a 3-sigma (99.7%) confidence level calculated from the Taylor and Southon (2007) data. Error bars are 1-sigma (65%) significance. Thus, the majority of R.E. Taylor's own diamond ^{14}C measurements showed intrinsic radiocarbon to a very high confidence level.

Taylor and Southon (2007) concluded from these results that the amount of

radiocarbon above theoretical detection limits resulted from memory effects. However, they never provided specifics for such a hypothesis or how to test it, let alone demonstrate what feature(s) of their results are consistent with memory effects. Possibly Taylor and Southon simply declared memory effects as the cause instead of testing for or against radiocarbon being intrinsic to the diamonds. Attributing their results (Figure 3) to memory effects or any similar source of recent contamination would provide a shield behind which billion year age assignments might hide from young-looking intrinsic radiocarbon.

The RATE results add similar arguments. Six measurements, with no background subtraction, of diamonds from various African mines (Baumgardner, 2005, p. 611) displayed ^{14}C in amounts at least 10 times greater than the sensitivity limit of the AMS system and approximately 1.5 times greater than the laboratories' 99.7% detection limit of 0.08 pMC. The same AMS laboratory also performed ^{14}C measurements on 6 alluvial diamonds from Namibia (Baumgardner, 2005, p. 612). All results displayed ^{14}C in amounts significantly above AMS sensitivity limits without the "standard background" subtraction. Table 2 reproduces the RATE summary of these results. With background subtraction, the five samples from the Kimberlite pipe diamonds average out to 0.04 pMC; still at least 4 times the sensitivity limit of the AMS system. The seven alluvial samples average 0.12 pMC; at least 12 times the sensitivity limit of the AMS system and 30% higher than the 99.7% detection limit. Figure 4 displays the results for the five samples from the Kimberlite pipe and the alluvial diamond from Guinea with the lowest measured pMC along with the AMS sensitivity threshold. This experimental evidence suggests that future investigations will continue to find intrinsic radiocarbon in any terrestrial carbon source.

Table 2. AMS ^{14}C measurement results for twelve diamonds, five from the African kimberlite pipe and seven from African alluvial deposits. All have the laboratory's standard background correction (0.08 pMC) applied. Table reproduced from RATE, vol. II. (Baumgardner, 2005, p. 614).

Sample ID	Geological Setting	Country	$^{14}\text{C}/\text{C}$ (pMC)
Kimberley-1	kimberlite pipe (Kimberley)	South Africa	0.02 ± 0.03
Orapa-A	kimberlite pipe (Orapa mine)	Botswana	0.01 ± 0.03
Orapa-F	kimberlite pipe (Orapa mine)	Botswana	0.03 ± 0.03
Lethakane-1	kimberlite pipe	Botswana	0.04 ± 0.03
Lethakane-3	kimberlite pipe	Botswana	0.07 ± 0.02
Kankan	alluvial deposit	Guinea	0.03 ± 0.03
NMBclr1	alluvial deposit	Namibia	0.31 ± 0.02
NMBclr2	alluvial deposit	Namibia	0.17 ± 0.02
NMBclr3	alluvial deposit	Namibia	0.13 ± 0.03
NMByel1	alluvial deposit	Namibia	0.09 ± 0.02
NMByel2	alluvial deposit	Namibia	0.04 ± 0.02
NMBrn2	alluvial deposit	Namibia	0.07 ± 0.02

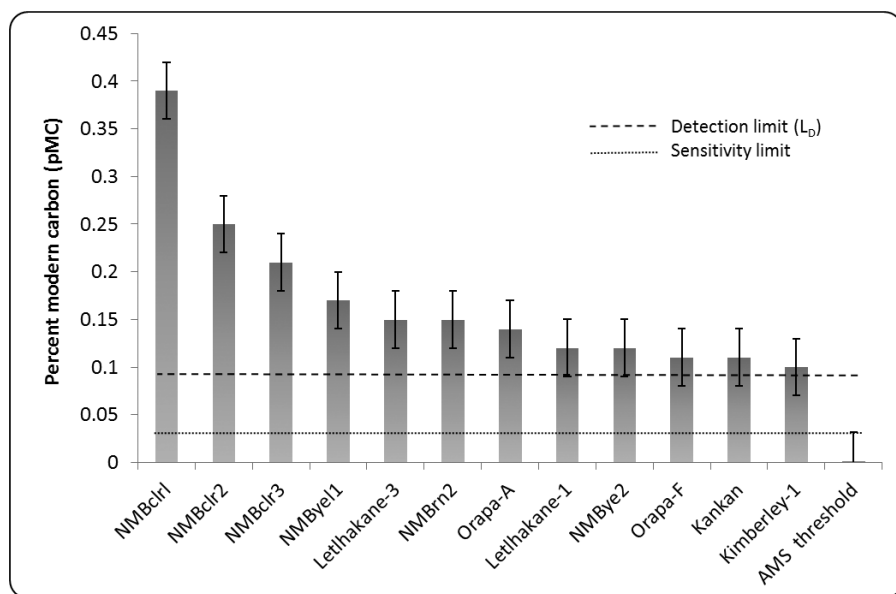


Figure 4. RATE diamonds show with 99.7% confidence that residual/intrinsic ^{14}C is present in nine of twelve measurements.

Additional examples of radiocarbon in very old carbonaceous samples including fossils could be given to demonstrate radiocarbon levels far above AMS sensitivity limits and in some cases above instrument backgrounds. Fig. 5 offers nine fossils with pMC ratios far enough above instrument background for AMS procedures to determine finite ages. All data in Fig. 5 are discussed in detail in Thomas (2019).

Conclusion

Taylor, Southon, and Santos (2018) claim that those who suggest that radiocarbon is intrinsic to geological samples misunderstand AMS background measurement principles. That thesis finds its support in the philosophical constructs of uniformitarianism, but not in measurements or science. Difficulty finding a suitable background sample appears to be a significant challenge facing radiocarbon measurements in AMS systems and not the existence of “erroneous backgrounds.” To argue that all the radiocarbon measurements, which clearly demonstrate the presence of ^{14}C in material deemed to be older than 60,000 years by the secular community, arise from erroneous background assessments uses circular reasoning. It assumes that the machine blanks are carbon dead despite the fact that they consistently contain more radiocarbon than both the AMS theoretical sensitivity limit and the approximate 99.7% confidence level detection limit. Taylor, Southon, and Santos (2018) fail to address this, even though it reflects the main problem with low level ^{14}C measurements. Instead, the consistent problem of detecting radiocarbon well above instrumentation detection thresholds in a variety of supposedly carbon dead earth materials including coal, limestone, marble, and diamonds suggests that these materials have been incorrectly assigned excessive ages. An objective scientist, unbiased by uniformitarianism, would look at the

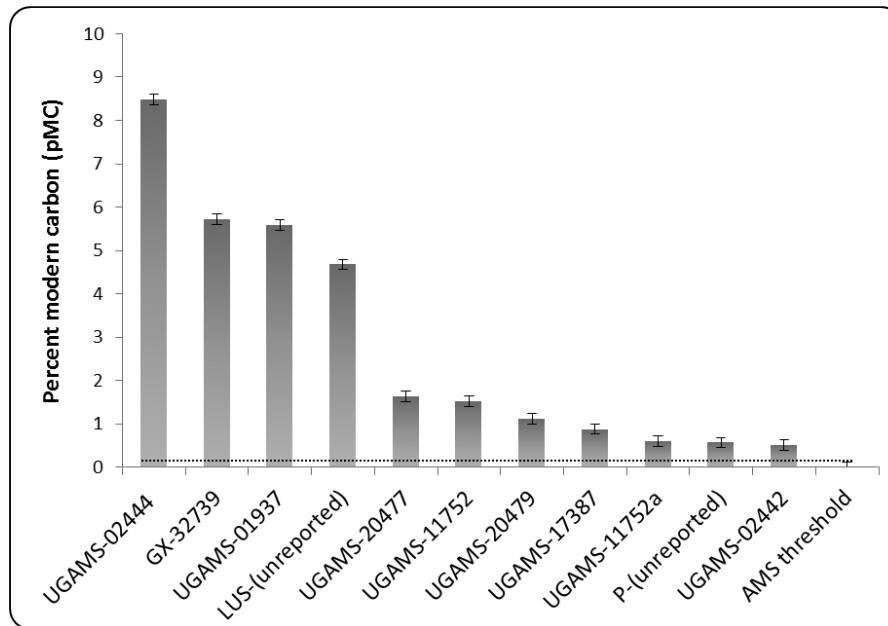


Figure 5. Eleven radiocarbon measurements of fossil samples all occur above the estimated instrument sensitivity (dashed line). Data represent four laboratories, two published results (LUS, and P), eight Cretaceous fossils, one Cretaceous matrix sample (UGAMS-02444), one Jurassic (UGAMS 20479), and one Ediacaran fossil.

evidence and seek a more plausible explanation than erroneous backgrounds or improbable contamination for ever-present radiocarbon in terrestrial material. The radiocarbon measurements that Taylor and colleagues (2014, 2018) want to dismiss suggest instead a need for a critique of standard geological dating methodologies.

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The Doctrine of Illumination and the Interpretation of Scripture: Considerations for Recent Creationists

Lee Anderson Jr.*

Abstract

Drawing from the author's personal encounters with misconceptions of the doctrine of illumination among recent creationists, this paper seeks to caution against overextending biblical teaching on the subject. This paper surveys numerous contemporary perspectives on the doctrine, and then discusses exegetical details within relevant biblical texts that impinge on a theological formulation of the doctrine. In going on to offer a synthetic theological view of illumination, this paper concludes that the Holy Spirit's work of illumination enables the believer to recognize Scripture for what it really is (the word of God), to grasp its principle spiritual teachings, and to appropriate the truth of the text; but that illumination does not ensure the correct interpretation of any scriptural passage apart from careful exegetical work involving the application of consistent hermeneutical principles. The illumination of the Holy Spirit does have a relationship to gaining a proper understanding of spiritual truth (which is contained in Scripture), but that understanding resides much more in the dimension of discernment and application of truth, and decidedly less in the dimension of acquiring a cognitive comprehension of that truth. Finally, the paper offers a number of correctives for recent creationists in the interpretation of Scripture.

Introduction: Creationists and the Doctrine of Illumination

Between 2013 and 2017, I worked in the research department at one of the major young-earth creationist ministries in

the United States. While working there, though I was encouraged to see enthusiastic support for defending biblical inerrancy and biblical authority, especially in relation to the early chapters of

Genesis, I was equally discouraged to see the degree of carelessness and sloppiness evidenced in the work of several of my colleagues concerning the application of hermeneutical principles and the interpretation of specific textual issues. In confronting some of these shortcomings, I repeatedly encountered a presumption that the Holy Spirit's work of illumination somehow served to (at least help)

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guarantee that Christians, regardless of their comprehension of the factors pertinent to sound exegetical method, would arrive at the correct interpretation of the biblical text—no matter how complex the passage(s) in question.

On one occasion, after demonstrating through rigorous exegetical arguments that the views of my colleague on a certain interpretive issue simply could not be correct (and thus should not be published), I was informed that the ministry leadership would not reject his perspective. Why? Not because he had presented adequate lexical, grammatical, syntactical, contextual, historical, or intertextual arguments in his favor; but rather because he, as a Christian, had the benefit of the Holy Spirit's ministry of illumination—which supposedly helped to ensure that he had arrived at a sufficiently accurate interpretation. Other exchanges allowed me to see that this perspective was fairly widespread among those working in other creationist ministries as well—especially with individuals not having a background in formal biblical and theological studies.

One particularly intriguing thing about this perspective on illumination is that it seems often to be assumed, but almost never defended textually. This led me to wonder whether the passages in Scripture that outline the doctrine of inspiration actually provide *any* support for the perspective that I commonly encountered. This paper is the result of my studies on the subject.

The Fundamental Problem with the Doctrine of Illumination

In trying to properly understand the Holy Spirit's ministry of illumination, the student of Scripture is faced with several challenges. One significant challenge is the comparative absence of detailed treatments on the subject of illumination in theological literature. Writing in the mid-1980s, Fred H.

Klooster observed, "The illumination of the Holy Spirit is regularly mentioned in theological literature; yet detailed discussion of this subject is rare" (Klooster 1984, 451).¹ Similarly, Carl F. H. Henry observed, "Theologians can write volumes on the Bible with not even a single index reference to the Holy Spirit's work of illumination" (Henry 1999, 273).² In spite of certain recent efforts to reverse this observed trend, it remains true today that the doctrine of illumination has not really received the attention it deserves; it tends to be, of the ministries of the Holy Spirit, one that is rarely well understood. To what may this shortcoming in evangelical theology be attributed?

Kevin D. Zuber charges that there are multiple reasons why illumination has remained so difficult to grasp theologically. First, several divergent definitions of illumination have been set forth, definitions that commonly express disagreement with respect to "that which is legitimately and essentially an aspect of illumination and that which is not" (Zuber 1996, 6).³ This is further complicated by a sometimes imprecise use of the various terms that are employed to define the Holy Spirit's work of illumination, and the relationship that it bears upon understanding the meaning of the written word of God (Zuber 1996, 6–10).⁴ Correspondingly, there has been confusion resulting from disagreement

over the results or outcomes of illumination (namely, what it *does* with respect to the apprehension of the Scriptures), as well as the relationship between illumination and the internal witness of the Spirit (that is, His work of conviction regarding Scripture's authority) (Zuber 1996, 10–15).⁵ However, what Zuber discerns as the greatest concern is that "little attention has been paid to establishing the biblical grounding for this commonly understood concept." Regarding the literature, "those who discuss the topic of illumination have not been particularly concerned to make definite the connection between their own statements about illumination and the biblical data relevant to illumination" (Zuber 1996, 15). Certain verses are commonly used to support particular perspectives on the doctrine of illumination, but often it is not shown from careful exegesis of these verses how they contribute to *developing* the doctrine of illumination (Zuber 1996, 16).⁶ This has led, in some cases, to an overextension of the Scriptures' teachings on illumination: First, it is maintained that illumination enables a believer, by the aid of the Spirit, to gain "insight into the meaning of the text"; it involves the acquisition of "a deeper understanding of the meaning that is there [in the text]" (Erickson 1993,

1 Klooster writes that discussion of the Spirit's "internal testimony" is generally more common and more extensive than that on illumination.

2 That Henry should be so appalled by this is understandable, for his work demonstrates that the role of the Holy Spirit in relation to Scripture is a critical point for consideration.

3 Zuber gives three contrasting examples of definitions from Fuller, Erickson, and Pannenberg.

4 Zuber points specifically to the words "meaning" and "understanding" as needing

to be more carefully defined in endeavoring to comprehend the doctrine of illumination.

5 For one perspective on the precise distinction between these two aspects of the Holy Spirit's ministry, see Grant R. Osborne (2006, 436). Note also on the internal witness of the Spirit the study by Bernard Ramm ([1959] 2011).

6 This is also an observation arising out of the arguments made by Douglas Kenard (2006, 797–806) and Bill Arp (2011). Ultimately, the basis of the doctrine in the text is of utmost importance to rightly understanding it.

54).⁷ This is then, unfortunately, taken by well-meaning but naïve believers to mean that illumination *ensures* that the interpreter who has the Spirit dwelling within him can be assured of the accuracy of his interpretation of the text.

Against this perspective, this paper will seek to demonstrate that the Holy Spirit's work of illumination enables the believer to recognize Scripture for what it really is, the word of God; to grasp its principal spiritual teachings (namely, the Gospel of Jesus Christ); and to appropriate the truth of Scripture—such that its teachings are received, its promises are depended on, and its commands are obeyed. Correspondingly, this paper will show that neither the Spirit's presence in a believer's life, nor His work of illumination, is sufficient to *guarantee* the proper interpretation (or, for that matter, application) of any passage of Scripture apart from careful exegesis by means of the application of consistent hermeneutical principles. To this end, this paper will overview, in brief, the different perspectives advanced on the doctrine of illumination and the place that it has in the interpretation of Scripture. It will also summarily examine the biblical passages relevant to formulating an understanding of illumination. It will then conclude by offering a basic definition of illumination, followed by some considerations on practical implications that the Spirit's work of illumination holds for the Christian seeking to rightly interpret the text.

Various Perspectives on the Doctrine of Illumination

The views advanced regarding the Holy Spirit's work of illumination can be divided into three basic groups. The first of these perspectives proposes, as

⁷ Erickson's quote is representative of several other writers who will be surveyed in the section to follow.

alluded to above, that illumination helps the interpreter of Scripture to gain—or at least to *better* gain—a cognitive understanding of the biblical text. An example of this perspective appears in Robert L. Plummer's treatment on the subject: "The Spirit brings to the Christian greater cognitive understanding of the biblical text" (Plummer 2010, 144).⁸ In his doctoral dissertation on illumination, Zuber likewise acknowledges that the end results of illumination are "primarily cognitive," and, accordingly, that "illumination enables one to gain a deeper grasp and comprehension of the content of a divine disclosure." Strikingly, Zuber goes on to assert that "One illumined is actually able to 'see,' mentally grasp, more of the content [that is, of revelation in Scripture] than one who is not illumined" (Zuber 1996, iii–iv).⁹ This makes for a sharp distinction in interpretive ability by those illumined by the Spirit versus those not illumined.

Similar views on the doctrine of illumination have been advanced by other scholars. W. Randolph Tate notes that some evangelicals take the term to refer to "the work of the Holy Spirit in elucidating some passage of the Bible for a person while studying" (Tate 2012, 207).¹⁰ This definition is echoed by Paul

⁸ In defense of this perspective, Plummer maintains the fact that nonbelievers are able to understand portions of the text is a testament to the clarity of Scriptures and God's common grace.

⁹ Zuber goes on to illustrate his point through appeal to common experience, saying, "the conceptual insight provided by illumination is like the insight one comes to when a line drawing in which one 'sees' an object is suddenly 'seen as' another object. The onlooker simply experiences a conceptual *gestalt* that enables more of the content to be seen."

¹⁰ It is not clear whether this is Tate's own view, but he does regard it as a noteworthy position.

Enns, who says of illumination that it is "The ministry of the Holy Spirit in enlightening the believer, enabling the believer to understand the Word of God" (Enns 1989, 637).¹¹ Henry Clarence Thiessen likewise notes concerning the Spirit's ministry, "Because of sin and the darkened understanding brought about because of sin, no one can understand Scripture properly (Rom. 1:21; Eph. 4:18). But the Spirit can enlighten the mind of the believer to understand Scripture" (Thiessen 1979, 63).¹² The remarks by Erickson concerning illumination, mentioned earlier, similarly assert that the Holy Spirit gives "insight into the meaning of the text," and that illumination brings "a deeper understanding of the meaning that is there [in the text]" (Erickson 1993, 54; and 2013, 216–225¹³). Charles C. Ryrie also observes that "illumination relates to that ministry of the Holy Spirit that helps the believer understand the truth of Scripture." He goes on to say that "ultimately it is the Spirit who is the direct connection between the mind of God as revealed in Scripture and the mind of the believer seeking to understand the Scriptures" (Ryrie 2001, 590–91; cf. Ryrie 1986, 131–32 and 1997, 198).¹⁴

¹¹ The difficulty that is inherent in this definition is, of course, the fact that there is no express mention of *how* or *to what extent* the Spirit enables the believer to understand the word of God. It is these factors that will play a critical role in the discussion of illumination which will follow later in this paper.

¹² In defense of his view, Thiessen appeals to 1 Corinthians 2:6–16; Ephesians 1:18; and 1 John 2:20, 27.

¹³ The latter of these is perhaps one of the best exegetical treatments on illumination which advances this perspective.

¹⁴ Ryrie appeals in his argumentation to John 16 and 1 Corinthians 2–3. He does include a caveat about nonbelievers being able to comprehend the meaning of the biblical text. Still, it seems he regards illumination

Such a position easily leads to the incorporation of illumination into the hermeneutical process, which is what Roy B. Zuck argues for in his article on hermeneutics: “The Holy Spirit... is available to help believers ascertain the correct meaning of the Bible’s statements, commands, and questions. He is involved in the hermeneutical process because He is ‘the Spirit of truth,’ who, Jesus said, ‘will guide into all truth’ (John 16:13). And, as Paul wrote, ‘We have... the Spirit who is from God, that we may understand what God has freely given to us (1 Cor. 2:12)’” (Zuck 1984, 120).¹⁵ Since “meaning” is imbedded in the text, the illuminating ministry of the Holy Spirit helps in the hermeneutical process by “repeating [i.e., reinforcing] the grammatical sense of Scripture” (Henry 1999, 283).¹⁶

This understanding of illumination carries over into practical areas of the believer’s life, such as preaching and prayer. John MacArthur submits that “Illumination is the work of the Holy Spirit that opens one’s spiritual eyes to comprehend the meaning of the Word of God. It involves the preacher of Scripture and his audience” (MacArthur 1992, 103). Also, MacArthur argues that “God’s objective and historically past revelation cannot be understood accurately apart from the present, personal, and subjective work of the Holy Spirit” (MacArthur 1992, 103). Illumination “causes enlightened understanding of doctrine and how it should be applied

to life” (MacArthur 1992, 103). Regarding illumination and prayer, Wayne Grudem notes that, in the light of 1 Corinthians 2:12, 14–15, “We [Christians] should pray that the Holy Spirit would give us his illumination and thereby help us to understand rightly when we study Scripture or when we ponder situations in our lives” (Grudem 1994, 645).¹⁷ Grudem contends that illumination is that for which the psalmist was seeking when he offered up to the Lord his petition in Psalm 119:18, “Open my eyes, that I may behold wonderful things from Your law” (NASB).

While surely there can be no objection to praying for God’s aid in rightly interpreting the Scriptures, the question remains whether this actually falls within the purview of illumination as the Spirit’s work is described in the New Testament. Additionally, this outlook on illumination is problematic, for it does not account for how nonbelievers are able to understand the biblical text, sometimes with a level of competence far beyond the average believer.¹⁸ Furthermore, this view is altogether vague in explaining *how* precisely the Holy Spirit is involved in the interpretation of Scripture. It seems to extend beyond the promises of Scripture to suggest that the Spirit interjects Himself into the

believer’s practice of the interpretation of the text.

An alternative view on illumination is that the Holy Spirit’s work involves enabling the believer not to understand the meaning of the text cognitively, but to understand it experientially. It concerns more the “receiving” (as true) the teachings of Scripture than having a mental grasp of what they teach (see especially Fuller 1997, 91–92). In this perspective, the Holy Spirit’s role in illumination is not to enlighten the mind to what Scripture is saying (for that much is clear to anyone who is willing to put forth the necessary effort in careful exegesis, applying proper hermeneutical principles); instead, His role is “to change the heart of the interpreter, so that he loves the message that is conveyed by the historical-grammatical data” (Fuller 1997, 92). Only a believer who has already had his heart inclined to the one true God by the Spirit’s work of regeneration (see Titus 3:5) can be receptive to illumination, so defined. Daniel P. Fuller insists that illumination involves God, working through the Holy Spirit, to replace the believer’s (natural) foolish desire for “ego-fulfillment” with the “reasonable, well-advised desire to find peace and joy in depending on God to stand by his promises” (Fuller 1997, 94). Thus, the Holy Spirit’s work of illumination enables the believer to receive the word of God as true and to respond to it in a way consistent with it being authoritative revelation.

Clark H. Pinnock expresses similar ideas, though sometimes using language that might make some conservative evangelicals uncomfortable. He maintains that the goal of illumination is for the Holy Spirit to work in the lives of believers to shed light on the Scriptures and thus to “deepen [their] friendship with God” (Pinnock 1993, 493). Illumination causes the Christian to be “drawn closer to God’s heart”; illumination ought to produce change in the life of the believer, with the principle

as substantially cognitive; it is a matter of aid in “understanding.”

15 In this role, the Spirit, says Zuck, helps to guard the believer against making inaccurate interpretations—with the result being an incorrect application of the text and, thus, misguided living.

16 Henry makes a critical contribution at this juncture, stating that in this, the Holy Spirit “in no way alters or expands the truth of revelation.”

17 It may be noted as a caveat that Grudem is not altogether clear on what he means by “understand.” This appears to be a real challenge in the works of a number of theologians on this point.

18 This is especially the case with various Jewish exegetes who, despite not accepting the Gospel of Christ and not having the indwelling Holy Spirit, have regularly produced outstanding commentaries on the Scriptures that (aside from being masterful treatments of the text from a literary standpoint) tend to exhibit a mature awareness of the authors’ theological messages, as well as of the implications of Scripture’s meaning for life.

emphasis being on “areas of growth and discipleship” (Pinnock 1993, 494, 496). The focus of this paper does not permit for a full investigation of the theological underpinnings of the perspective advanced by Pinnock and Fuller; however, it is fair to say that their view makes some meaningful contributions. Most significantly, though, as it concerns the Spirit’s work of illumination in relation to understanding Scripture, the question may be asked whether what is described in this perspective is really what Scripture means in the passages that concern illumination. Surely, the place of the Holy Spirit in the life of the believer to bring about spiritual growth through submission to the word of God is not in question. However, is this really *illumination*, strictly speaking? Or does this fall under the broader work of the Holy Spirit in *sanctification* (Rom. 8; Gal. 5)? Also, is the idea of a changed heart really in primary focus in the biblical passages concerning illumination?

The third major view on the Holy Spirit’s work of illumination—which arguably stands somewhere between the other two perspectives—is that illumination concerns the Holy Spirit’s role in giving to the indwelt believer “a dynamic comprehension of the *significance* of Scripture and its *application to life*” (Klein, Blomberg, and Hubbard 2004, 139).¹⁹ Thus illumination results in the believer being able to take a full and solid grasp of the significance of spiritual truth. It works in tandem with, and not apart from, the application of a sound exegetical method in order for the text to achieve its ultimate purpose in the life of the believer (which involves trust in the truth of Scripture and obedience to it). The Spirit, in His ministry of illumination, works to enable the

believer to “embrace” what Scripture teaches and to rightly apply the truth of the text (note Kaiser and Silva 1994, 168). This does not cut off the mind from the work of biblical interpretation, but it does suggest that the Spirit’s work in illumination is not mainly cognitive. Such helps to account for why there are so many skilled interpreters of the biblical text who are not believers and who do not have the indwelling Holy Spirit (Kaiser and Silva 1994, 168).

In this perspective, the Spirit does indeed help the believer to “understand” Scripture; but the word “understand” in this view should not be regarded as merely the ability to mentally grasp the linguistic content of God’s word; instead, it goes beyond having a cognitive understanding of the text to *also* being able to recognize its existential value.²⁰ In this view, “knowing” the truth of Scripture is tied to an appropriation of its significance. As such, “According to Scripture, persons do not truly possess knowledge unless they are living in light of that knowledge. True faith is...knowledge acted on.” Thus, it is correctly observed that “The unbeliever can *know* (intellectually comprehend) many truths of Scripture using the same means of interpretation he would use with non-biblical texts, but he cannot *know* (act on and appropriate) these truths as long as he remains in rebellion against God” (Virkler and Ayayo 2007, 28).²¹ The

20 Graham A. Cole (2007, 266) notes that “understanding” is a problematic term in the discussion of illumination. It can be taken in different ways in order to advance different positions.

21 Virkler and Ayayo (2007, 28) likewise note a *cognitive* aspect of this problem: “Scripture teaches that yielding to sin causes an individual to become enslaved to it and blind to righteousness (John 8:34; Rom. 1:18–22; 6:15–19; 1 Tim. 6:9; 2 Pet. 2:19).” Unfortunately (but quite commonly) “the truth principles in Scripture, available

Spirit’s work of illumination thus chiefly concerns the efficacy of the word of God; He “brings home” the literal meaning of the text to the reader, impressing on him “the full force of a communicative action” (Vanhoozer 1998, 427; see also pp. 428–29). To state it succinctly, “The Spirit thus opens readers’ hearts and minds so that the words [of Scripture] can produce all their intended effects: effects of illocutionary understanding and effects of perlocutionary obedience” (Vanhoozer 1998, 428). Osborne observes that passages like 1 Corinthians 2:14 and 2 Corinthians 4:4, which concern the blindness of the unsaved to spiritual truths, do not mean that unbelievers “cannot understand the *meaning* of the text but rather that they will reject the *implications* of it.” He goes on to say, “The Holy Spirit deals in this latter realm [regarding implications], enabling readers to separate truth from falsehood and to apply the Word properly in their lives” (Osborne 2006, 437).²² Accordingly, J. Scott Duvall and J. Daniel Hays give this

through application of the same skills of textual interpretation used with nonbiblical texts become progressively less clear to one who continually rejects those truths.” As such, “Unbelievers do not *know* the full meaning of scriptural teaching, not because that meaning is unavailable to them in the words of the text, but because they refuse to act on and appropriate spiritual truths for their own lives.” Ultimately (and sadly) “the psychological results of such refusal make them less able and willing to comprehend these truths.” So it is fair to say that while the *principle thrust* of illumination is not cognitive, the absence of the Holy Spirit’s involvement in biblical interpretation leads to terrible cognitive *and* spiritual consequences.

22 This, Osborne observes, comes “through the mind and study of the interpreter” (Osborne 2006, 436). Thus, the mind is not bypassed; however, more is involved in “understanding” than just the reader’s mental faculties.

19 Emphasis original. This simple definition of illumination shows a balance between emphasis on the cognitive and the spiritual, comprehension and application.

summary: “When it comes to biblical interpretation, the Spirit appears to work *little* in the cognitive dimension, *more* in the area of discerning truth, and *most* in the area of application” (Duvall and Hays 2005, 208).²³ As such, within this perspective, illumination is a complex work of the Spirit related to the believer’s apprehension of the biblical text in the most meaningful way possible.

Exegetical Evidence Regarding the Doctrine of Illumination

This overview of the different views on the Holy Spirit’s work of illumination necessarily leads to a consideration of the handful of texts appealed to in the discussion of the subject. Those on all sides of the discussion recognize that a theological understanding of illumination, however it is to be defined, emerges out of a relatively limited number of critical passages: John 14–16, 1 Corinthians 2, Ephesians 1, and 1 John 2 (and possibly Ps. 119:18, Luke 24, and 2 Tim. 2). These texts’ significance for the doctrine of illumination has already been examined by Cole (2007, 263ff.), Arp (2011, 4–27), and Kennard (2006, 799–803). As such, this paper will aim to survey and summarize the contributions of these passages rather than giving a detailed exegetical treatment of them.

John 14:26. In John 14:26, Christ promised His disciples that He would send the Spirit, who would “teach [them] all things,” and would “bring to [their] remembrance” all that He said to them. This passage has been used to argue that the Holy Spirit’s work in illumination has an effect on the believing reader’s ability to understand (cognitively) the word of God (see, e.g., Gru-

dem 1994, 645; cf. Erickson 2013, 219). However, it must be noticed that this promise of Christ is given to the Apostles (less Judas) and it concerns the teachings that Christ had communicated to *them*. It bears a connection to the Apostles being enabled to receive and proclaim new revelation (cf. John 15:26–27). Yet there is nothing in this passage which suggests that this promise is transferrable to all believers generally;²⁴ additionally, there is no indication that this promise has anything to do with the *written* word of God. Indeed, that would be too much to infer from the literary and historical context of John 14:26, especially since the Gospels had not—at the time of the promise—been written. It is therefore erroneous to maintain that this verse promises any help to the believer in cognitively understanding Scripture; it is arguably not even directly relevant to the discussion of illumination (Kennard 2006, 800).²⁵

John 16:13–15. John 16:13–15 contains the promise of Jesus Christ to His disciples that the “Spirit of truth” would come and “guide [them] in all truth.” The promised Spirit would not speak on His own initiative, but would speak in accordance with “whatever He hears”; so too, it is promised that He would “disclose to [them] what is to come.” This is, like the preceding

24 That this promise is specifically for the Apostles is indicated by the fact that the verse’s two clauses are linked. It is illegitimate to take the first statement (“He will teach you all things”) in reference to all believers, but to regard the second statement (“He will bring to remembrance all that I said to you”) as it surely is intended, that is, in reference to the Apostles alone. Such is inconsistent.

25 Kennard argues, however, that this verse (along with John 16:12–15) still has “great benefit for Christians in that they reassure us that John wrote these statements accurately by the Spirit’s aid” (Kennard 2006, 801).

verse, used to argue for the Spirit’s aid to believers to cognitively comprehend the words of the text. In particular, backers of this view home in on the promise that the Spirit will guide the recipients of the promise “into all truth” (Ryrie 1986, 132; cf. Erickson 2013, 219). Plummer goes so far as to claim on the basis of this passage that “All Christians are assured the supernatural presence of the Holy Spirit, who will teach them and protect them from all error” (Plummer 2010, 180). It is bewildering how Plummer justifies this understanding in light of how prone many believers are to theological error; but a discussion of that issue is beyond the purview of this paper. In any case, attempts to use this passage to endorse a particular outlook on the Spirit’s work of illumination—especially one in which the Spirit aids the believer to develop a correct cognitive understanding of a given passage—run up against the same concerns as those expressed in relation to the preceding passage. Plainly, this promise is for the disciples, and there is no hint (much less a guarantee) that the promise extends to all believers (Arp 2011, 10). As with the preceding passage, it is illegitimate to separate the components of the promise—making some out to be for just the Apostles, and making some out to be for all believers. John 16:13 plainly links the disclosure of things to come (which certainly concerns prophetic revelation) with the promise to guide the recipients of the promise into all truth. Again, this promise is for the Apostles, not believers generally, and it likewise does not have in view the interpretation of written revelation.

1 Corinthians 2:6–16. In 1 Corinthians 2:6–16, Paul speaks about the revelation of God’s wisdom—a work in which the Holy Spirit is active (see especially verse 10). In verse 12, the text indicates that believers have received “the Spirit who is from God” so they “may *know* the things freely given to [them] by God” (emphasis added). Verse

23 It follows, therefore, that there are multiple (legitimate) answers to the question “Can a nonbeliever understand the word of God?”

14 states that the “natural man,” that is, the nonbeliever, “does not accept the things of the Spirit of God” and indeed “cannot understand them, because they are spiritually appraised” (emphasis added). The contrast, therefore, between the Christian and the non-Christian is that the former has the Spirit who enables understanding of truth about spiritual matters, whereas the latter does not. While the *written* text is not mentioned explicitly, such is a natural implication: the Holy Spirit enables believers to receive Scripture for what it really is—the true word of God (cf. 1 Thess. 2:13) (cf. Cole 2007, 265–66). However, it may still be asked what bearing this has on biblical interpretation. Some expositors appear to connect 1 Corinthians 2 to the idea that unbelievers unaided by the Spirit have some lack of cognitive ability to understand the truth of Scripture (Plummer 2010, 147; cf. MacArthur 1992, 102, 105–06; Walvoord 1991, 220). However, this does not seem to be the real thrust of Paul’s teaching. By saying that believers are taught to *know* the things of God, while unbelievers *cannot understand* them, Paul is focusing on an *understanding* pertaining to significance for life—not the ability to cognitively grasp the meaning of the message. The unbeliever rejects the things of the Spirit of God (namely, the truth of the Gospel) as “foolishness” (verse 14), which implicitly assumes that the nonbeliever may cognitively grasp the things which Scripture teaches (Stein 1994, 66–67).²⁶ Obviously, this does have import for the study of Scripture; yet it is not a promise concerning the believer’s ability to be able to draw from the Scriptures the meaning of a given text. The promise that the “spiritual” man will be able to

appraise all things because he possesses the “mind of Christ” (verses 15–16) does indicate that the believer may, in dependence on the Holy Spirit, discern and embrace the truth as it concerns spiritual things; but it does not promise the enablement to correctly interpret and apply a given passage of Scripture. It is not a *hermeneutical* promise (cf. Kennard 2006, 802).

Ephesians 1:17–19. Ephesians 1:17–19 (especially verse 18) is often critical to the case of those seeking to support a view of illumination in which the Spirit enlightens the believer to a better understanding of Scripture (see, e.g., Grudem 1994, 645). In this passage, Paul prays the “eyes of [believers’] hearts” would be “enlightened” so that they would know (1) the hope of God’s calling, (2) the riches of the glory of God’s inheritance in the saints, and (3) the great magnitude of God’s power toward those who believe, which is in accord with “the working of the strength of His might” displayed in the resurrection and ascension of Christ (verses 18–21). Though it is important to note in this passage the gift of enlightenment that God grants (verse 18), it is inconclusive whether this may be linked with the Spirit’s work.²⁷ Admittedly, it is *logically viable* that the indwelling Spirit be involved in this enlightenment, and Paul does say later in Ephesians 3:16–19 that God’s Spirit is involved in granting to the believer a comprehension of the love of Christ—an important spiritual truth. And yet, there is no *exegetical* connection to be drawn between this work of the Spirit and the task of biblical interpretation. This is therefore not a promise concerning the Spirit aiding the

believer in the hermeneutical process or granting insight in interpretation.

1 John 2:20, 27. The promises concerning the Holy Spirit in 1 John 2:20, 27 are generally used in a way that is similar to those passages previously discussed in support of an illumination that concerns the believer’s ability to understand Scripture. For example, Plummer connects this passage with John 16:13–15 in arguing, “All Christians are assured the supernatural presence of the Holy Spirit, who will teach them and protect them from all error” (Plummer 2010, 180). The Apostle John, in this passage, identifies an “anointing” (χρῖσμα) believers have received from “the Holy One.”²⁸ This anointing “teaches” believers “all things,” to the end that they would continue to abide in Christ. The surrounding context indicates that what is at stake in this passage is discernment between the truth of the Gospel and the false messages of deceiving antichrists (verses 18, 22). Accordingly, the point is that believers are equipped to hold on to the truth of the Gospel in the face of the lies of those who would twist the Gospel message and deny the Lord Jesus Christ. It is a theological leap to move from the principle of spiritual discernment highlighted here to an argument for the Spirit’s aid in the hermeneutical process (Cole 2007, 265–66). The “anointing” does teach believers about all things, such that, in view of the truth of the Gospel of Jesus Christ, they can look at all other things with a correct

²⁶ Likewise, in the context of 1 Corinthians 1–3, it can be seen that God Himself *understands* the “wisdom” of the world, but rejects it as foolishness. This parallel in Scripture is quite striking.

²⁷ Harold W. Hoehner, on the basis of the two genitives that follow the mention of the word “spirit” in Ephesians 1:17, declines to take the verse as a reference to the Holy Spirit, but rather reads it as referring to a disposition or attitude (Hoehner 1983, 620).

²⁸ Bruce (1970, 71) offers argumentation that the “anointing” spoken of by John is the Holy Spirit (cf. 1 Cor. 1:21–22). Kennard (2006, 802) says that the Spirit is not in view, but rather the anointing is “truth heard”—truth that centers on Christ and the Gospel. It may be granted that Kennard is correct that the doctrine of illumination has been overextended, but it seems equally an overextension to deny a reference to the Spirit here; such is an *appropriate* inference.

perspective and avoid being susceptible to Gospel-denying lies; but there is no specific promise about the Spirit helping believers to cognitively understand the text (Kennard 2006, 802).

Other Passages. Psalm 119:18, Luke 24:45, and 2 Timothy 2:7 are also appealed to in the discussion of the doctrine of illumination. While the two New Testament verses do speak about a sort of enlightenment of believers' understanding from God, it is noteworthy that neither passage mentions the Holy Spirit. As for Psalm 119:18, in which the psalmist prays that God would open his eyes, so that he could behold the "wonderful things from [God's] law," the Spirit is likewise not in view.²⁹ This is not to say that the prayer of Psalm 119:18 is inappropriate for believers today to pray; indeed, it is good to ask the Lord for His help in grasping the meaning and significance of His word, especially for the purpose of applying it rightly, which is the thrust of the context in Psalm 119 (see, e.g., verses 1–16). However, Psalm 119:18 does not provide an exegetical basis for claiming that the Spirit interjects Himself into the hermeneutical process.

Developing Conclusions Concerning the Doctrine of Illumination

The preceding summary has shown that the biblical basis for asserting that illumination involves the Holy Spirit's work to help the believer cognitively understand the text of Scripture is very marginal. That said, the disagreement on the subject is excusable, for, as Carl R. Trueman observes, "The relationship of the theological concept of illumination to biblical interpretation is not straightforward" (Trueman 2005, 318). Still, in light of the (lack of) biblical evidence, and in view of the fact that nonbelievers *are* able to understand the

literary and exegetical meaning of the text—sometimes with far greater insight and hermeneutical competence than believers—the idea that illumination is the Holy Spirit's work in helping the believer to gain a special cognitive understanding of the Bible must be rejected as inconsistent with both Scripture and experience.³⁰

What then *can* be determined from the biblical data as to the work of the Holy Spirit in illumination? First, the Holy Spirit is involved in God's work of enlightening a believer, so that the Christian is able to appraise spiritual truth (1 Cor. 2:12, 14–15; cf. 1 Thess. 2:13). The Spirit, correspondingly, enables the Christian to embrace and appropriate grand spiritual truths—truths which are central to the message of Scripture, such as the power of God and the love of Jesus Christ (Eph. 1:18–19; 3:16–19). In this, the Spirit as "teacher" equips Christians to be on guard against the lies spread by enemies of the Gospel message, discerning truth from error (1 John 2:20, 27). Because the Spirit's ministry concerns truth, there is a connection to be drawn between it and the Scriptures—but not such that it may be claimed the Spirit interjects Himself into the process of biblical interpretation. Gordon R. Lewis and Bruce A. Demarest express this conclusion with a great deal more eloquence, and they deserve to be quoted at length:

The witness of the Spirit attests the objective truth and meaning of spe-

30 The great competence of some nonbelievers in understanding the literary meaning of the biblical text is showcased in an illustration provided by Kaiser and Silva, in which they note that a nonbelieving teacher expounded with marked excellence the message of the Gospel from Romans. The teacher, although having a superb grasp of the meaning that Paul intended, did not accept the meaning as true to reality (Kaiser and Silva 1994, 167–68).

cial revelation, beginning at its heart, the gospel. The Spirit inspired the content of the gospel in the Scriptures, and now the Spirit persuades sinners of its truth objectively for all and internally for themselves. In this persuasion the Spirit may use different amounts of the relevant exegetical, historical, literary, and cultural data discovered by long hours of hard study by the inquirer or the ones ministering the Word to him. Hence the gospel appears no longer as foolishness or a stumbling block. The mind, desires, and will are opened to Christ and then makes the commitment to him as Savior and Lord (1 Cor. 2:14; 12:3).

Enabled by the Spirit, believers trust and experience God's purposes of redemptive grace (1 Cor. 2:12). They are no longer in bondage to the values of the natural man (v. 14) and grow in evaluating things according to the revealed mind of Christ (v. 15–16; 1 John 2:20–22, 27).

God's Spirit abides with believers, enabling them to receive the things that come from him (1 Cor. 2:14). That applies particularly to the Spirit-revealed and Spirit-inspired Scriptures. (Lewis and Demarest 1996, 168)³¹

To summarize again, the Spirit's work of illumination enables the believer to recognize Scripture for what it really is (the word of God), to grasp its principle spiritual teachings, and to appropriate the truth of the text. But illumination does not guarantee the correct interpretation of any scriptural passage apart from careful exegetical work involving the application of consistent hermeneutical principles. The doctrine

31 Notably, Lewis and Demarest also draw a connection between the Spirit's work of illumination and His work of granting the believer assurance of salvation (cf. Rom. 8:15–16; Gal. 4:6).

29 See discussion on page 226, above.

of illumination is not a safeguard against sloppy Bible study! The illumination of the Holy Spirit does have a relationship to gaining a proper understanding of spiritual truth (which is contained in Scripture), but that understanding resides much more in the dimension of discernment and application of truth, and decidedly less in the dimension of acquiring a cognitive comprehension of that truth. There is therefore a need for balance in how believers talk about illumination. Trueman perceptively observes that “Too much emphasis on illumination as providing the content of Christian belief [that is, making out illumination to be the primary key in the process of interpreting/understanding the Scriptures] can render biblical interpretation an essentially gnostic activity, which places the views of those who have been ‘illuminated’ beyond the criticism of those who have not” (Trueman 2005, 318). However, to ignore the doctrine of illumination altogether, and to dismiss the Spirit’s role in enabling believers to rightly approach and receive the truths of Scripture is also hazardous. As Mike Stallard observes, “The theological task [and the exegetical component thereof] is not just an academic discipline but a spiritual enterprise. It involves spiritual gifts (Eph. 4, Rom. 12, 1 Cor. 12–14) given by the Holy Spirit not just intellectual skills. Therefore, practices such as prayer ([which] involves the Holy Spirit, see Rom. 8:26–27) are not out of place as part of the theological task” (Stallard 2009, 6).

In conclusion, a few words deserve to be said regarding the application of this outlook on illumination. First, because the Holy Spirit’s work of illumination does not function primarily on a cognitive level, giving the believer insight into the details of the biblical text in the interpretive process, the Christian should be careful never to presume upon the Spirit’s work of illumination so as to excuse sloppy hermeneutics

(cf. Kennard 2006, 805).³² Rather, the Christian interpreter must invest himself fully in the hard work of biblical interpretation, using all of the exegetical tools which are available to him in the process. The interpreter must heed the words of 2 Timothy 2:15 to “accurately handle” or “rightly divide” the word of truth. Creationists, in particular, must not presume that just because they are starting with the correct macro-theological perspective on protology (i.e., recent, supernatural creation) they are immune to error in the particulars of textual interpretation. More specifically, creationists with a background in the scientific disciplines must be especially sensitive to the nuances and challenges pertaining to the disciplines requisite to textual interpretation (e.g., hermeneutics; Hebrew lexicography, grammar, and syntax; ancient Near Eastern history and culture; biblical and systematic theology; etc.)—disciplines in which they very rarely have any substantive formal training.³³

32 It should be noted that none of those named above who suggested that the Holy Spirit interjects Himself into the cognitive aspect of biblical interpretation by helping the reader to “understand” the text argued that careful exegetical work should be sacrificed. The Holy Spirit, in all of their discussions on illumination, was to be regarded as working in and through the normal process of biblical interpretation, not against it or apart from it.

33 Inattentiveness to the principles and nuances of these disciplines results in skewed interpretations that can become ingrained in the collective thinking of the creationist movement. An example of this concerns scientists in the early days of the modern creationist movement (including Henry Morris and Emmett Williams) who read “very good” in Genesis 1:31 to preclude the existence of the second law of thermodynamics. I have since shown that this is not a valid inference from the language of Genesis 1:31 (“very good” entails the

Second, relatedly, the believer should never claim illumination as a basis for being overly dogmatic in his interpretation of specific passages, especially where it concerns the finer details of the text (Zuck 1984, 122). In recent years, creationist resources have become much more focused, moving from being (typically) general defenses of biblical history and biblical authority related to the early chapters of Genesis, to being interpretive guides on specific textual issues. Whereas creationists often excelled in the former, where broad-based theological arguments were concerned, they have struggled with respect to the latter, often showing ineptitude where detailed exegetical work is required.³⁴ As

concepts of completeness, fulfillment of purpose, and moral excellence—it does not require the absence of entropy; see Anderson 2013). Danny Faulkner, similarly, has written addressing the physical complications of Morris and Williams’ view (Faulkner 2013). However, these correctives would have been unnecessary if more care had been taken to accurately interpret the biblical text in the first place, applying a working understanding of Hebrew lexical study.

34 I have sought to confront and correct some of these exegetical missteps in my earlier published works. For example, in a 2017 paper (Anderson 2017a), I show that the Tablet Model (the view that the sections of Genesis divided by the word *tôlēdôt* were written by prominent figures appearing in the respective narratives, and that these sections were later compiled by Moses) is lacking on exegetical grounds. The Tablet Model (1) ignores the compositional unity of the book of Genesis that defies the notion of it being a compiled document, (2) dismisses the internal evidence of Genesis pointing to its composition in the 15th century BC, and (3) misreads the *tôlēdôt* markers as colophons rather than transitional headings, among many other problems. The solution, I maintain, is for creationists to return to the traditional view of Mosaic authorship, in

such, creationists must be exceptionally careful about being rigidly dogmatic where minute details of Scripture are concerned; and they certainly ought never to appeal to illumination to excuse such unjustified dogmatism.

Third, though the Holy Spirit is the believer's teacher (1 John 2:27), the believer must be careful to take into account the teaching of other godly Christians, whether this comes in the form of direct teaching in a sermon, or "vicarious teaching" in, for example, quality literature. (The teaching that comes through commentaries and other Bible study tools is a very important part in the task of biblical interpretation.) Creationists, in particular, must not be dismissive of (scholarly) work on Genesis (or other pertinent sections of the biblical text) set forth by biblical scholars. Many recent works on textual issues by those involved at the major creationist organizations have shown a grave lack of attention to technical writings by dedicated biblical scholars.³⁵ This needs

which Moses (*perhaps* using oral or written source material for portions of his work) actually *writes* (rather than compiles) the book of Genesis. The critical point in this discussion is that our view of Genesis' composition needs to be determined by detailed *exegesis* of the relevant portions of the biblical text, and not by (as with the Tablet Model) an artificial paradigm imposed on the text's structure and narrative.

35 An example of this shortcoming in the creationist literature is exposed in my response to Jonathan Sarfati's letter to the editor "Toledots and Creationist Positions," entitled "A Response to Sarfati: Omission of Source Deliberate" (Anderson 2018). In particular, I observe that any creationist work that presumes to address the compositional origin of the book of Genesis really must interact with Duane Garrett's magisterial treatment on the subject, *Rethinking Genesis*. Similarly, in my critique of John Hartnett's writings on time dilation cosmological models, I observe that

to be corrected. Additionally, *creationists must not neglect pertinent biblical scholarship by evangelical scholars who reject recent creation*. For while these scholars err in this critical matter, they still often have much to offer with respect to the exegesis of particular passages and the resolution of certain difficulties in the early chapters of Genesis.³⁶

he does not, in any of his writings defending his more recent perspective on the matter, "engage in robust, methodical lexical, grammatical, syntactical, structural, contextual, or theological analysis of the biblical text. Nor does he consult any commentaries, Bible dictionaries, lexicons, grammars, or other appropriate theological resources. Indeed, such interaction may have led creationist scientists to take a more nuanced approach to this issue in the first place" (see Anderson 2017b, 204, emphasis added; note also on page 210 the accompanying list of Hartnett's publications on time dilation cosmological models). As scholars dedicated to upholding a biblical view of origins, we who are within the modern creationist movement need to stop taking our own written contributions so seriously (as if they were all there is to say about the topics they address) and learn to responsibly interact with the broader scope of literature from the biblical disciplines—even if we find that our own views are sometimes challenged or dismissed.

36 Consider, for example, the work of Kenneth A. Mathews (1996) who, though apparently rejecting recent creation (p. 149), provides exceptional insight on Genesis 2:4ff. concerning the theological reason for the use of the otherwise rare combination יהוה אֱלֹהִים (*Yahweh Elohim*) (pp. 192–93). Likewise, C. John Collins, who stands strongly opposed to recent creation, offers much help in tracing out the theological significance of Genesis 2:24 as it concerns the doctrine of marriage (Collins 2006, 142–45). His handling of this verse and its intertextual connections to other Old and New Testament passages is superb. In both of these cases, it would be regrettable to dismiss out of hand the respective

Fourth, the believer should reject the urge to presume that, because of the indwelling Holy Spirit, his own interpretive conclusions—or those of another believer—are *necessarily* better than those of a non-Christian interpreter. While it may be true that non-Christians have produced interpretations of virtually every passage in the Bible, often twisting the words of Scripture so as to make them read contrary to the author's intended meaning, the fact remains that there are many works by nonbelievers—especially Jewish works on the Old Testament—that handle the text admirably well and that offer profound insights into the meaning of the Scriptures. Notably, creationists' works have evidenced a conspicuous lack of interaction with premier Jewish source material (such as, e.g., the detailed exegetical commentaries by Cassuto and Sarna), thereby missing the helpful insights they so frequently offer. Yes, errors in their overarching theological perspective (especially as it relates to Christology) cannot be ignored. But the fact remains that their interpretive work in Genesis ranks among the best produced to date.

With respect to these areas of application, the point advanced in this paper is plainly evident: nonbelievers can, with the proper application of consistent hermeneutical principles, attain to a correct understanding of the biblical text. However, the fact remains that only believers, all of whom have dwelling in them the Holy Spirit (Rom. 8:9), are able to *truly and fully understand* the profound significance of Scripture so as to embrace it for what it is—the word of God—and apply it rightly to life. Illumination does not substitute for careful exegetical study, nor does it guarantee the correct interpretation of Scripture apart from

author's perceptive treatment of the verse/subject addressed due to disagreement with him on the interpretation of Genesis 1 and the age of the earth.

the proper application of sound hermeneutical principles. However, only by the Holy Spirit's work in illumination will the believer properly appropriate the truth of Scripture such that, ultimately, its teachings are accepted, its promises are depended on, and its commands are obeyed. Creationists who know the Lord Jesus Christ as their Savior (and indeed all believers) may rejoice in this certain truth.

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Mammoth Trapping in the Yukon:

A review of Northern Tutchone oral history evidence supporting the survival of Woolly Mammoths in the Yukon Territory within the past 1,000 years

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Abstract

This paper is a multi-disciplinary review of the Northern Tutchone oral history concerning encounters with Woolly Mammoths in their traditions. A comparison is made with similar traditions of other North American indigenous people, and this is reviewed against evidence for the existence and hunting of woolly mammoth in North America. The Ice Age geology and archaeology of the Yukon Territory is considered, coupled with wider oral histories of the other indigenous peoples who use Athapascan languages. This locates the Northern Tutchone in Yukon Territory only within the past 1,000 years. The Northern Tutchone legends are shown to contain credible descriptions of encounters with woolly mammoth, which implies the relatively recent survival of these animals in the Yukon. A discussion of the history of woolly mammoth and other Ice Age fauna in the Yukon concludes with an examination of some major finds of animal remains, and the problems of radiocarbon dating in this context. It is argued that the wide disparity between radiocarbon dating of Ice Age fauna and flora found in the Yukon and the multi-disciplinary evidence supporting the oral history of the Northern Tutchone casts doubt on the reliability of radiocarbon dating in this context. Dates between 600 and 1,000 years ago are proposed for the events behind the Northern Tutchone mammoth legends.

Introduction

In the heart of Yukon territory, about 180 km from Whitehorse along the Klondike

highway is the small town of Carmacks, for most of its history little more than a trading post on the Yukon river, and

for several decades a supply point for firewood to the steamboats on the Yukon river (Fig. 1).

The “First Nation” (indigenous) people for whom central Yukon is home are the Northern Tutchone, who speak one of the Athapascan group of lan-

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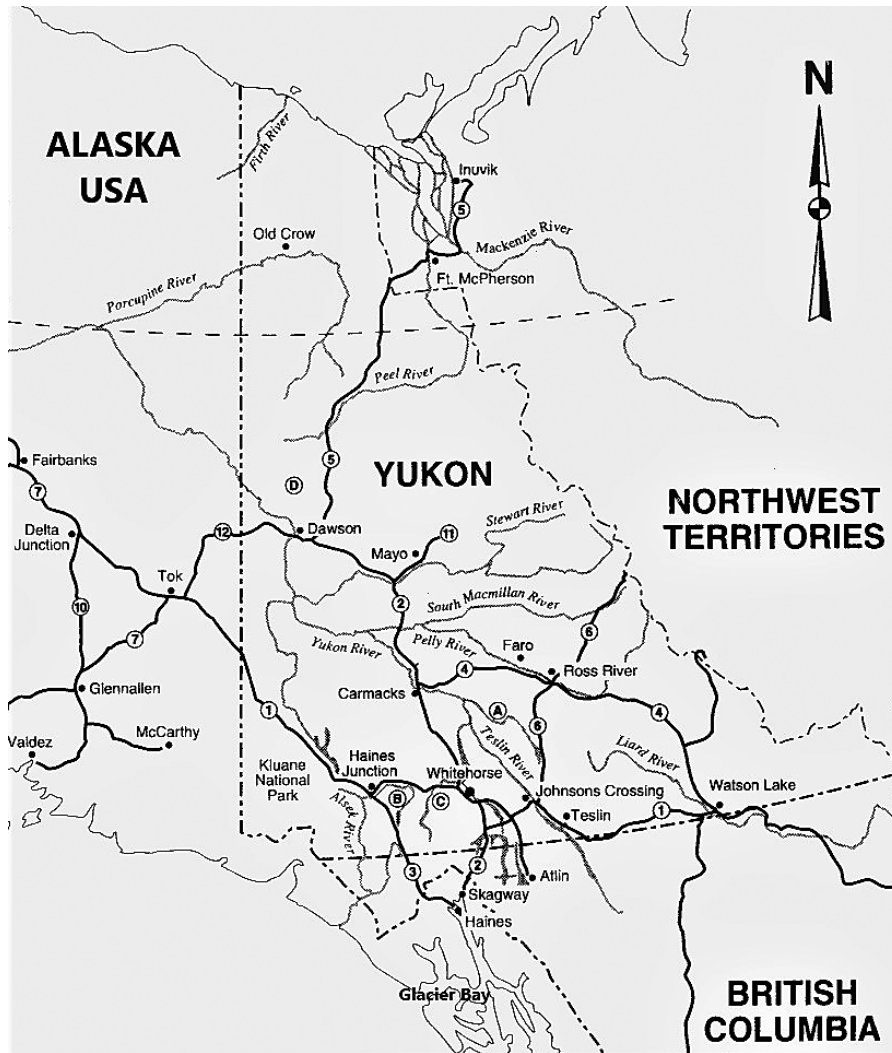


Figure 1. Map of Yukon Territory

guages (McClellan 2007). They have a visitor centre beside the highway in Carmacks with many exhibits showing their history and culture. Their traditions are based on the historical memories of their people, some of which are on display (Fig. 2). They have recorded three different accounts of how their ancestors encountered, were killed by, and in turn killed mammoths. The most startling exhibit is a model of a Mammoth trap, built according to the specifications handed down to Elder Wilfred Charlie:

The snare or trigger is a line made of babiche (i.e. cord made of hide or sinew) crocheted together. This is strung among some trees, which have been cut part way through. When the mammoth comes through the trees, the line pulls all the trees down on him. Clubs were used to kill the mammoth then... One time, when people snared a mammoth, its foot was thumping on the ground while he was pinned under the trees. People made him turn his foot over. If the foot points down, it

means that people are going to die. When the foot points the other way, it means that people are going to live. (Charlie 1986)

The notice under the model says:

The legend of how Northern Tutchone snared and killed mammoths was first recorded here in Carmacks. During the end of the existence of this huge animal it seems to have become a threat to humans.

The Northern Tutchone devised this elaborate snare system to rid the land of their most feared predator. People dressed up in their best clothing in case they died in the fight with the mammoth. If the mammoth died with his feet up it meant good luck.

The last mammoths were not eaten since the Northern Tutchone did not eat any animal that ate humans. The bones of the last mammoth that was killed in the Frenchman Valley are reported to be still there but have not been found yet.

The legends give the following specific details, which are important in trying to evaluate the veracity of the reported encounters with mammoths:

1. The mammoth trap is a type of snare and deadfall combination.
2. The mammoths so trapped were killed with clubs.
3. The mammoths attacked the homes of the people.
4. The mammoths were believed to be man-eaters, and therefore were not killed for food.
5. The killing of mammoths was regarded as an important event, to be done while wearing the best clothes, because of the risk of being killed by the mammoth.
6. The climate when this was happening was becoming very cold, so that the Northern Tutchone were constructing their homes out of brushwood and pouring water over the outside, where it froze and gave them strong walls of ice (which

defended them during attacks by mammoths).

7. The posture of the mammoth when it died had mystical importance (“luck”—a life or death matter—depended on whether a mammoth’s foot was pointing upwards or downwards).

Questions

To confront this graphic evidence of people encountering a creature supposedly extinct “at the end of the last Ice Age,” we must consider two main questions:

1. To what extent can these mammoth legends of the Northern Tutchone be validated?
2. If they can be, when did these events take place?

Yukon Valley—Background

The Yukon River rises in the mountains of British Columbia, flowing 3,190 km north and west through the Yukon Territory into Alaska, emptying into the Bering Sea. The current population of Yukon Territory is around 35,000, some 25,000 of whom live in Whitehorse. The remaining 482,000 km² of the territory outside Whitehorse is very sparsely populated, and (except for the Gold Rush years) always has been. From around the start of the 17th century, Yukon natives were trading in European goods with Russians and British traders who came either from the west, along the Yukon River, or from the east, traders of the North West company, and later the Hudson’s Bay company. To the south, trade was handled via the Tlingit people of the Alaskan coast. In the late 19th century, gold was discovered in the alluvial gravel beds near where the Klondike River joins the Yukon at Dawson City. In general terms, directly above the bedrock is the alluvial gravel where gold is found. This is covered by a surface layer of “muck” (i.e. various



Figure 2. Mammoth Trap model, Carmacks, Yukon Canada

unconsolidated silts with ice and other material which can be up to 20 meters thick in the Klondike area).

Figure 3 illustrates the range of layers of unconsolidated material which may be found. You will see from this that mammal bones are found in silt layers above the gravel, and that there are likely to be many pieces of ice within the silt, as well as the larger sections of ice running upwards through several layers. The mammal bones uncovered are typically described as fossils, although they have not been permineralized (turned into stone, the normal definition of a fossil), and traces of DNA may be found within them (Willersley et al 2014). This is all usually found in a zone of permafrost, which poses two main challenges to miners, first that the permafrost has to be thawed to reach the gravel where the gold may be found, and second that the process of separating the gravel to find gold requires large volumes of water, which can only be done during

the summer months when the rivers are not frozen.

Scores of square kilometers of valley bottom land near Dawson City have been mined down to bedrock, leaving vast areas of washed gravel tailings. This has resulted in the discovery within the “muck” of animal remains in prolific quantities. Some 80% of all remains are those of the now-extinct Steppe Bison, while the best-known are Woolly Mammoths. In addition, discoveries include Mastodon, Horse, Lion, Scimitar Cat, Giant Ground Sloth, Giant Beaver, Western Camel, Giant Camel, Elk, Caribou, and Peccary. Some animals have been found partly preserved by the permafrost, showing they were frozen very soon after death, but they have usually been disarticulated, that is, torn apart before being deposited. The dates attributed to the remains found generally range from 300,000 BP (Before Present) to about 10,000 BP, though separate evidence has been found of

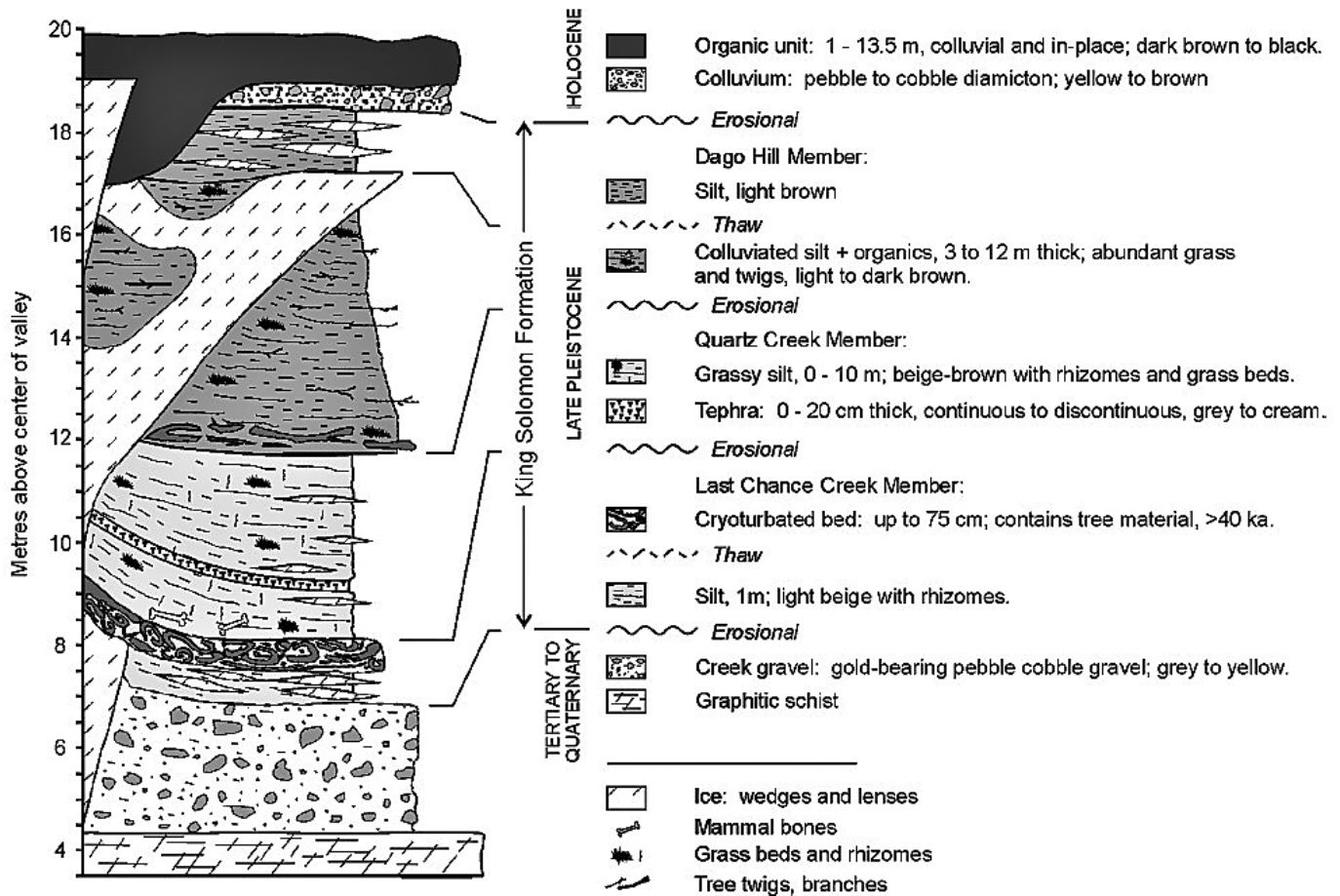


Figure 3. Representative section of Klondike Muck, (Kotler and Burn. 2011).

Steppe Bison surviving as recently as 400 years ago (Harington 1996). Most writers describe the main extinction of these “Ice Age Mammals,” including mammoths and steppe bison as happening about 10,000 BP (Harington 2003).

The conventional explanation of these remains involves a series of Ice Ages over 300,000 years or more, with intervening warm periods. The quantity of mammoth remains found indicate there was once a very large number of them in the Yukon region. Giant Ground sloths and peccaries are among the creatures found that are known to require a much warmer climate than has been seen in this region in historic times (the area currently has a Subarctic climate). The

sea levels of the Bering and neighbouring Chukchi Seas have been found to be as much as 120 meters lower than today (Sancetta et al. 1985; Keigwin et al. 2006), creating a sub-continent-sized area of dry land connecting Siberia and Alaska known as Beringia, which provided a route for people and animals to travel between Asia and North America. Sea levels are believed to have risen following the melting of ice at the end of the Ice Age.

While most of central and northern Yukon was never glaciated, the regions to the south and over the mountains to British Columbia and southern Alaska were. There were some large glacial lakes. Glacial Lake Champagne (Gilbert

and Desloges, 2005), filling many valleys in southern Yukon, is estimated to have covered a few thousands km², and was around 200m deep. It has left several residual lakes, including Lake Kluane (408 km²) and Lake Kusawa (142 km²), where evidence has been found for several level changes. The later Neo-Glacial Lake Alsek was at maximum extent 100 km long and 200 m deep (Clague and Rampton 1982). There is evidence for “catastrophic outflows,” and three successively smaller versions of this lake (Hefner 2008). Some more recent glacial lakes have suddenly emptied causing floods as recently as the 19th century AD (Cruikshank 1981). Such flood events can be triggered by melting

glaciers, landslides, and earthquakes, all of which are common in the region (Brideau et al 2004).

There has been a lot of volcanic activity in the wider region, and the volcano Mt Churchill (Alaska) last erupted about 1,100–1,200 BP with a force far greater than Mt St Helens (erupted 1980 AD), ejecting some 30 times as much material (est. 50km³). It covered a large area of the southern and central Yukon with ash, with ash layers now found between 3 and 10 cm, and would have probably made this area uninhabitable for many years (West 2007).

In general, there is clear evidence in the Yukon for the existence of large numbers of mammoths, and of early human habitation contemporary with these Ice Age mammals. It will be shown that it is unlikely that the Northern Tutchone are connected with these archaeological discoveries.

Oral History

The oral traditions of the various Indigenous peoples of Alaska, Yukon and Northwest Territories have been closely studied for the best part of a century (Cruikshank 1981), in common with similar studies across the whole of North America (Sinha and Sinha 1968). Initially, researchers were sceptical that the oral histories (including songs and stories) could contain much information that could be assigned to dateable events, but by the 1970s, this had changed. Archaeologists had confirmed stories from the Paiute and Hopi dated to events in the 12th century AD, while a Tlingit (Alaska) story locating a village built around 1400 AD (Cruikshank 1981 p. 83), beneath a glacier for most of the past three centuries, was confirmed in the 1950s. It has been found that several Athapascan-speaking tribes outside the Yukon have maintained legends of a massive volcanic eruption that have been traced to Mt Churchill, over 1100 BP (Fast 2008). This is the remotest

dateable event so far identified in their oral traditions.

Traditions have been proved very accurate when it comes to cataloguing and describing wildlife and plants of all kinds, and how to make snares and traps to capture creatures like the Caribou. There is also much information about the movements of glaciers, and the filling and emptying of glacial lakes. Beyond that, stories move into the realm of myth (in the opinion of the anthropologists researching oral traditions). This includes the creation of the earth, and the great flood which destroyed everything but a few survivors and some animals. The difficulty with many of the legends is matching them to a modern chronology. For example, there are vivid stories of a year with “two winters joined together,” which researchers first understood was in the late 19th century, then realised that “grandfather’s time” could actually mean “grandfather’s grandfather’s time,” pointing to the early 19th century AD, and probably therefore 1816 AD, known in western circles as “the year with no summer” [attributed to the effects of the eruption of Mt Tambora, Indonesia, in April 1815 (Decker and Decker 1989)]. Traditions also set the last hunting of (now-extinct) bison in the eastern Yukon around then, about 200 years ago (Cruikshank 1981).

As far as the Tutchone are concerned, the fact that they have no tradition of a major volcanic eruption indicates they were not present at the time of the latest Mt Churchill eruption, and it has also been suggested that much of their present territory was in any event under water then (Fast 2008). This means that their mammoth legends presumably belong to a time within the last 1,000 years. The reference to “Frenchman’s Valley” (about 20km northeast of Carmacks) as a place where bones of a killed mammoth may be found sets the context for that event firmly in central Yukon. While no-one has found these bones, the paleontologist C. R. Haring-

ton in 1967 followed up a legend told him by a Gwitchin elder in Old Crow of “monsters” in the Whitestone River area and found the remains of a female mammoth (Harington 2008). The story was that a “monster” had broken out of a lakebed near the Upper Porcupine River, trudged up that river and died under a bank on the Whitestone River, a tributary of the Porcupine River. Harington speculated that the legend had been a result of a flash flood into the Porcupine River farther south cutting back the edge of the lake (and thus exposing the bones he found). Harington radiocarbon dated these remains to 30,000 BP, and his rationalisation seems an attempt to harmonise an apparently impossible narrative (in his view) with the historical reality. The alternative could be that someone saw an exhausted mammoth in a lake perhaps washed down in a sudden local flood which rose up out of the mud as it reached shallow water near the lake’s edge and then walked away and died. Harington’s discovery of mammoth bones in the area might then be pure coincidence.

The Northern Tutchone are only one of several indigenous North American peoples with legends of encounters with elephant-like creatures (Strong 1934). Some authorities attribute the creatures variously as mastodons or mammoths, both mammals of the order Proboscidea which includes elephants. It is not possible to use the legends to differentiate one type from another. All are very large, have tusks and trunks, and leave circular footprints, traits which feature in the descriptions. Mammoths were the most prolific of these creatures as so far known from remains discovered, and certainly the dominant Proboscidean species in the Yukon territory. Strong (1934) identified credible legends from the Abenaki, (other) Algonquians, Naskapi, Alabama, Koasati, Penobscot, Ohio, Ojibwa, Iroquois, Micmac, Chitimacha and Atakapa tribes, ranging from Louisiana to Nova Scotia. He mentioned

also tribal legends from Bering Straits and Alaskan Eskimo (Inuit) which he discounts. He does not mention any Yukon tribes.

Most of these other legends lack the sharp detail found in the Northern Tutchone legends, though hunting with arrows and traps is described. One interesting detail is that

the Alabama and Koasati Indians of the Southeast insist on translating man-eater (Atipa tcbá) as “elephant” (Strong 1934).

Mammoth hunting

One aspect of the legends we can test easily involves methods of hunting mammoths. There is a lot of evidence for mammoths being hunted by people, and this takes the form of such things as spear heads found in mammoth remains, the scars made by spears on mammoth bones, and other marks showing mammoths were butchered for food. It has also been observed that mammoths which fell into pits were unable to escape making pit traps feasible as they have been with elephant hunting in Asia and Africa. Agam and Barkai (2018) discuss several possible methods for hunting mammoths, using elephant-hunting methods for comparison. Known methods include using spears, axes, pitfalls, traps, arrows, fire, and dogs.

The mammoth encounters with the Northern Tutchone happen in the context of very cold weather, when the tree and log snare described would be easy to make, while digging pits would not be feasible.

There is no reasonable doubt that mammoths and mastodons were hunted by people, using methods like those described by the Northern Tutchone. The differences in detail (e.g. using clubs rather than spears, the deadfall trap) show that it is an independent narrative, not deriving from the other North American legends.

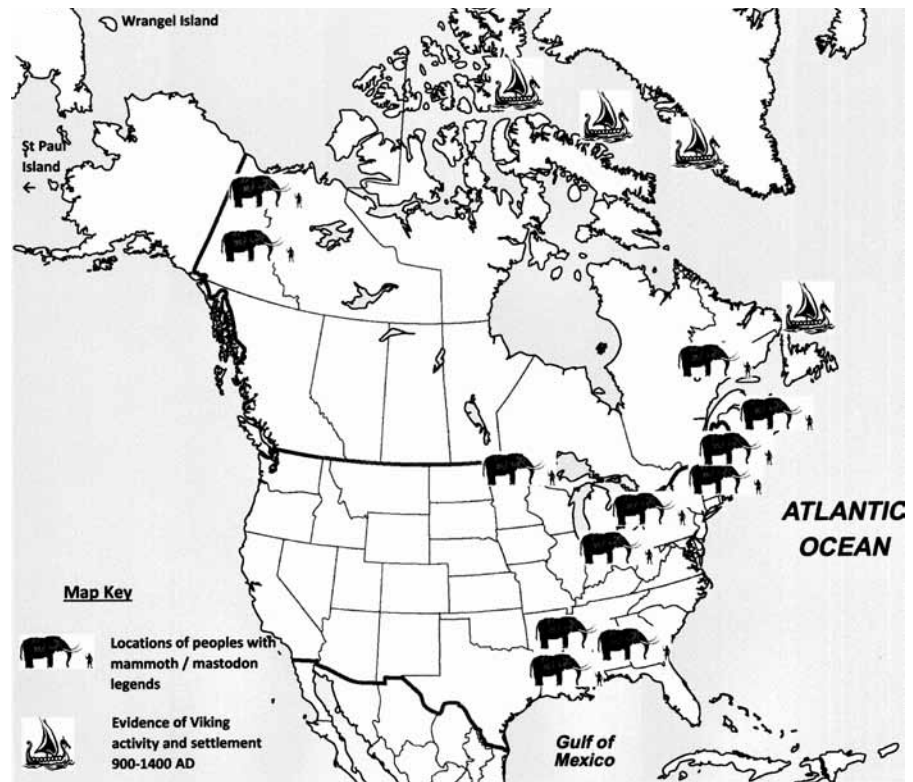


Figure 4. Map showing locations of the First-nation peoples reporting encounters with Mammoths or Mastodons, and northerly sites of known Viking activity during the Medieval Warm Period.

Figure 4 shows that most of the available legends originate with peoples in eastern USA and Canada, or in the southeast near the coast of the Gulf of Mexico. The Northern Tutchone legends come from an area that is well separated from most of the others, by both the Great Plains and the Rocky Mountains. The other legends also usually relate to encounters with no more than one or two mammoths/mastodons at most, whereas archaeological remains around the world evidence the destruction of large herds virtually simultaneously (Oard 2004). If these legends are rooted in fact, then most can only relate to encounters with sparse survivors of earlier events which wiped out the vast majority.

Man-eating Mammoths?

A serious problem to confront is the detail that at least one of the mammoths in the Northern Tutchone legends ate people. Mammoths are one of the few extinct creatures where preserved examples have been found with stomach contents that can be examined. The creatures were undoubtedly herbivores, just like the surviving varieties of elephants today. As they share so many features with mammoths, it is reasonable to explore elephant behaviour, and what is found that while normally elephants are herbivores, they sometimes attack houses and people and, very occasionally, eat them (Handwerk 2005, Hay 2015, Zelman 2011).

These aggressive behaviours by elephants are attributed to stresses caused by competition for land by people, food and water supplies being threatened, and hunting. It is thus easy to see how some mammoths could have turned to this kind of behaviour as a result of either being hunted or food shortages or both. Four of the peoples with mammoth legends elsewhere mention man-eating (Strong 1934).

Advancing Ice and Climate Change

The legends indicate that these events occurred at a time of increasing cold. So cold that you could pour water over the outside of your hut and it would freeze before it reached the ground, making walls strong enough to resist attacks by mammoths. For this you need two things, an outside air temperature below, say -10°C , and a supply of (unfrozen) water nearby—such as could be provided by a river like the Yukon before its surface froze solid, which nowadays normally happens after mid-November and until May (The process would have been like the formation of glaze ice: with an air temperature well below 0°C , and the (brushwood) surface of the shelter at air temperature, water would freeze on contact. Repeated applications of water would thicken the ice coating rapidly). -10°C is within the present range of temperatures in the Yukon Valley in November. At present, the climate is becoming warmer in this region, therefore we need to identify a time when the climate was becoming colder.

The most recent period when a warmer climate turned to a colder climate across the whole Northern Hemisphere is in the 14th century AD. In the four or five hundred years before then, the climate in northern Canada and Greenland was distinctly warmer than today, as demonstrated by the range of Viking settlements and artefacts discovered from this era (Fig. 4). This suggests

that the (currently Arctic) climate of Western Greenland was possibly cool temperate. The remains of hundreds of Viking-era farms with temperate-climate livestock along 450 km of the Greenland coast strongly indicate conditions very different to now (Wahlgren 1986). The beginning of the Medieval Warm Period appears to have coincided with the arrival of the Tutchone in the Yukon area. Today the climate of the Yukon is warmer than Western Greenland, so this is likely to have been the case then. The Medieval Warm Period was followed by “The Little Ice Age,” between around 1300 and 1870 AD, during which time glaciers in Alaska advanced, driving the Tlingits out of their Glacier Bay homeland (Bohrer 2016, Cruikshank 1981).

The mammoth legends must be more than 300 years old. The oral traditions do not assign them to any “grandfathers,” as was the case with bison hunting. There is no credible evidence for the survival of mammoths anywhere in the wider Yukon River region from the 17th century AD onwards, when trading contacts with Russian and British traders began.

Some Conclusions

We have seen that the oral tradition of Northern Tutchone about hunting mammoths should be regarded as credible because:

- Mammoths were undoubtedly hunted by people.
- The Northern Tutchone describe viable methods for hunting mammoths.
- The aggressive behaviour of mammoths (attacking homes and people, eating people) all falls within the known behaviours of stressed elephants, while the man-eating claim is strong authentication.
- The parallel with traditions about hunting the Steppe Bison, once thought to be long extinct, is a reminder of the possibility that

“newer” mammoth remains may yet be found.

- The corroboration by several other parallel North American Indigenous traditions of encounters with mammoth-like animals.

The Time of the Mammoth Encounters

In summary, these legends cannot be much more than 1,000 years old, because the Tutchone were not resident in the Yukon before then. Neither can they be less than 300 years old, because the oral tradition does not assign them such a recent date, nor is there any evidence from the trading connections that this was happening then. The cooling climate evidenced within the stories suggests a possible date at the onset of the Little Ice Age, therefore 6–700 years ago. This takes us to the main area of difficulty, current views on the timing of the extinction of the mammoths.

When Did the Mammoths Finally Die Out?

Archaeological evidence for mammoths being hunted by people suggests this was happening about 13,000 BP (Gill et al. 2009, Haile et al. 2009). Could the oral history have been accurately maintained as long as this? And how did they die in such vast numbers? Any search will reveal a bewildering array of theories for what caused the extinction of the mammoths. In recent years these have included: advancing forests, invasive grass species, a meteorite impact in Greenland, melting ice blocks, human “germs,” climate change, a comet explosion, over-hunting, disease, and a catastrophic weather event (Results of a Bing search engine query: “What wiped out the Mammoths?,” 23 December 2018). Michael Oard has argued for dust-storms as the main killer of the Siberian mammoths, while acknowledging that end-of-Ice Age flooding could explain the mass

deaths in other regions. He presents the argument that they increased in number rapidly after the (Genesis) Flood, from 2,300 to 1,800 BC during the advance of the Ice Age, with extinction beginning around 1,800 BC near the end of the Ice Age, and ending in 1,600 BC (Oard 2006).

Isolated groups of mammoths have been found which have been radiocarbon dated to 5,600 BP on St Paul's Island, Alaska, and 3,700 BP on Wrangel Island, off the coast of Siberia, some 5–7,000 years later than the conventional extinction date (Vartanyan et al 2008., Graham et al 2016). This is strong evidence for the possibility of groups of Ice Age megafauna including the mammoths surviving long after the majority of their species have died out, but even if we suppose similar dates could apply in the Yukon, there is still a gap of 3–5,000 years to bridge, or perhaps 2,500 years following Michael Oard's chronology. Could small groups of mammoths have survived this long? The Northern Tutchone legends describe not just small groups but very small groups (usually lone animals).

The longer the survival period, the greater numbers you would expect to find—even one thousand years in good circumstances could be enough time to produce more large herds. The legends therefore lead us to conclude there was a relatively short survival period for these mammoths; otherwise they should have been found in large herds like that better-known North American Ice-Age survivor, the American Bison.

Radiocarbon Dating Issues

The main basis for the dates cited for the remains of mammoths and other creatures found in the Yukon area is radiocarbon dating. The problem with this is that it is not as precise as is often supposed, and where it can be checked against known historical dates is regularly shown to overstate the age

of samples (as will be demonstrated below).

As the preservation of these remains has depended in every case on swift burial and freezing, the inconsistency is obvious. Studies of outburst floods, sudden releases of impounded water and sediment found in glacial lakes, show they have been known to produce layers of sediment matching or exceeding the total thickness of the Yukon and Alaskan “muck” deposits, complete also with the graded layers in a single event (Carivick et al 2007). The concentration of mammal remains in these deposits, usually in a single layer of silt, implies just one mass destruction, caused by a single flood event (Figs. 3, 5). Therefore, many of these remains with widely differing radiocarbon dates must have died at the same time

Stevens Village Alaska is some 600 km downriver from Dawson City. Figure 5 illustrates the nature of the problem. You can see (on the left) some 13 meters of deposits above the alluvium, with dates suggesting it took some 4,000 years or more to deposit this. You find rabbits both near the top and bottom of the sequence, while elk are located both below and in the middle of the bison. The combination of elk, bison, mammoth, and horse all occur in one layer, with bison both above and below as well. It is easy to picture this as the result of a single large outburst flood, resulting from the breaching of one of the great glacial lakes in Southern Yukon, and then you could picture the rabbits, some caught grazing in the open and some diving into their burrows when the flood comes. Those in the open would float near the surface. The elk, close kin to moose could have been divided between those swimming—diving even, as is known for moose, trapped by the sediments under water, while those caught grazing on land would be mixed in with the other grazing animals. As the bison comprised some 80% of all grazing animal remains, their sheer numbers

would have their bodies surrounding the other creatures. So what about the 4,000 year spread indicated by (calibrated) radiocarbon dating?

Radiocarbon Dating problems

A recent re-evaluation of human remains in the UK caused the adjustment (reduction) of radiocarbon dates by almost 200 years on bones of people who died in the winter of 873–874 AD. The spread was in the range of +6 – +17% on this relatively recent set of samples. This revision was forced by the inconsistency between the radiocarbon findings and the well-dated historical event concerned (Jarman et al 2017). (Johnson (2018) has argued that a main factor in this discrepancy is the Viking fish-based diet!). Another study of material about 7–800 years older, samples of mortar used in buildings in Pompeii and Herculaneum (destroyed by volcanic eruption 79 AD, samples from buildings constructed during previous 200 years) gave radiocarbon dates ranging from 2,400–5,800 BP. This is an error range from around +10% up to +290%. (Lindroos et al 2007). These two reports are unusual for presenting the full range of uncalibrated radiocarbon dates. More usually, the dates supplied are calibrated. Calibration means adjustment by removing the more extreme dates and subjecting the remainder to a statistical analysis, a method which can produce very flawed results, as these cases show.

Baumgardner (2005) has presented considerable evidence for the extreme unreliability of radiocarbon dating of the more distant past. He suggests that older radiocarbon dates may massively overstate the true age of the samples tested.

Conclusions

The Northern Tutchone legends of encounters with mammoths, and their trapping of them, are credible accounts of events, counter-intuitively reinforced

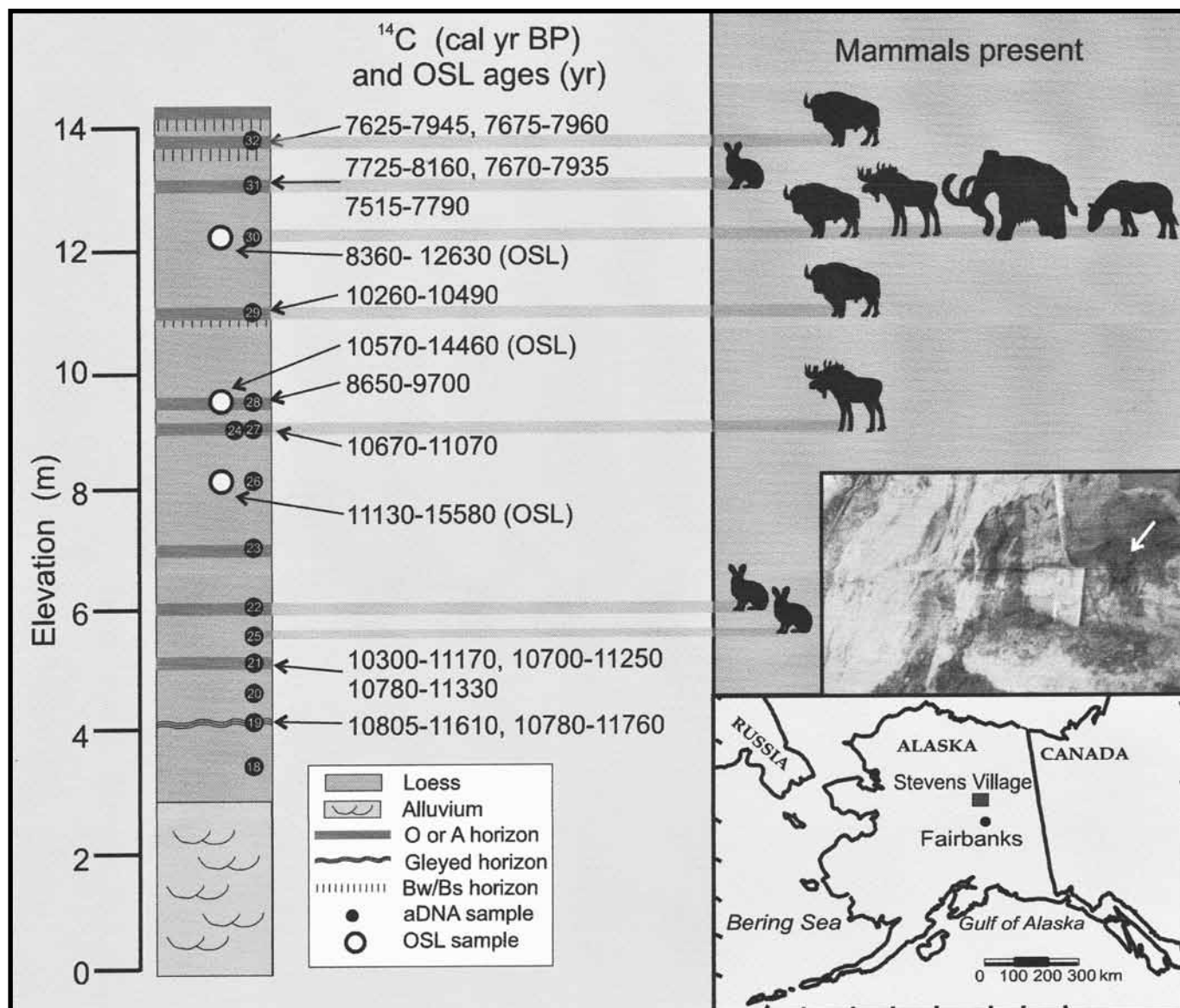


Figure 5. Stratigraphic profile of Stevens Village site, by James Haile et al (2009).

by the aggressive behaviour of the mammoths.

The probable sequence of events is that mammoths together with a wide range of other animals crossed Beringia before and during the early Ice Age, spreading from Asia into and throughout the Americas. They flourished in the warmer climate of Beringia away from

the main glaciated regions, until rising sea levels destroyed their main habitat. Herds survived in the Yukon region before one or more glacial lake breaches triggered massive outburst floods, wiping out those animals living on the valley floor. The flood waters tore the animals to pieces and deposited them mixed up with silt, ice and vegetation on top of

the gravel beds. A few animals further up the valley sides escaped, and survived for possibly some hundreds of years, in a progressively deteriorating climate, before encountering the newly arrived Tutchone people, who killed off the last stragglers. As the end of the Ice Age was not a sudden or precise event, the main Yukon Territory flood destruction could

easily have been as recent as 2,000 BP or later.

Dating the Northern Tutchone legends can be done by combining estimates of the possible decline in accuracy of oral history over time, noting their probable arrival in area about 1,000 years ago, and historic change from a warmer to a colder climate. The 14th century AD offers a very reasonable date for the final legends, with the others possibly dating from a few hundred years previously. The main alternative, that the legends relate to a timespan of around 10,000 years is simply not credible.

If the oral history of the Northern Tutchone is valid, then the radiocarbon dating of the remains in the Klondike muck cannot be. Of these two attempts to date history, one is based on:

1. Geological evidence of the Mt Churchill eruption, of which the Tutchone traditions show no sign.
2. Several separate examples of North American indigenous traditions being validated in recent years, with dates going back at least 1,000 years (including Mt Churchill).
3. The wholly credible (and counter-intuitive) nature of the northern Tutchone mammoth legends.

The other is based on a dating method that has been demonstrated to be inaccurate, and sometimes extremely inaccurate, when it has been tested. If the Northern Tutchone mammoth legends are accepted as valid, then it implies a much more recent date for the end of the “last” Ice Age, than (say) 10,000 BP, and the subsequent destruction of the mammoths among a wide range of other mostly now-extinct fauna.

If we accept the possibility of the late survival of herds of Woolly Mammoth in the Yukon, beyond, say, those in Siberia and Northern Europe, to as recently as 2,000 BP, then the Northern Tutchone legends make sense. The time scale proposed by Michael Oard fits better with the evidence from the Northern

Tutchone legends, but needs further adjustment to allow for later survival of woolly mammoths in the Yukon region.

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Letters to the Editor

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The African Plate and Spreading Ridges

Whether continental plates could have moved rapidly within a young-earth framework is a very controversial subject amongst creationists.

In the late 1960's, the days of the emergence of the acceptance of plate tectonics, Pavoni (1969, p. 57) wrote:

"The characteristic segmentation and apparent horizontal displacement of the oceanic ridges as well as the remarkable sharp bending of the magnetic lineation can hardly be explained by a convective upcurrent below the ridges. Sea-floor spreading is explained by assuming horizontal flow below the ridges."

This "horizontal flow" was later explained in Pavoni (1993). In Pavoni's unidirectional flow model, the plate speed east of the Mid-Atlantic Ridge is that of the African plate, close to zero, while the plate speed west of the ridge is much larger. (See Figure 1). In Figure 7b, page 74 of *Plate Tectonics: A Different View*, published by the Creation Research Society, this is misrepresented; the arrows do not convey the concept of Pavoni's Figure 6b, which shows the unidirectional flow with plate velocity larger west of the ridge axis.

Figure 2 shows the larger-scale picture in Pavoni's unidirectional flow model. Contrary to the outdated picture often shown in textbooks, upwelling is thought to occur beneath Africa, and horizontal flow in the upper mantle beneath the ocean ridges.

Thus the physics of relative motion is involved. The ridge itself is moving westward, while *relative to the ridge* the ocean floor west of the ridge moves westward and *relative to the ridge* the ocean

floor east of the ridge moves eastward (backward). The motion is symmetric with respect to an observer situated on the ridge and moving with it.

For example, suppose the "leading plate," the one west of the Mid-Atlantic Ridge, is moving westward at, say, 2.0 cm/year and the "trailing plate," the one east of the ridge, is stationary. The average of 2.0 and 0.0 is 1.0 cm/year, which would be the speed of the ridge axis also going westward. The ridge axis separates from the leading plate at $2.0 - 1.0 = 1.0$ cm/year. The ridge axis separates from the trailing plate at $1.0 - 0.0 = 1.0$ cm/year. There is symmetry in that both plates separate from the ridge axis at 1.0 cm/year.

Baumgardner (2001) recognized that the ridge axis would move, while not necessarily basing this on Pavoni's unidirectional flow model, when he wrote:

Pavoni's Unidirectional Flow Model

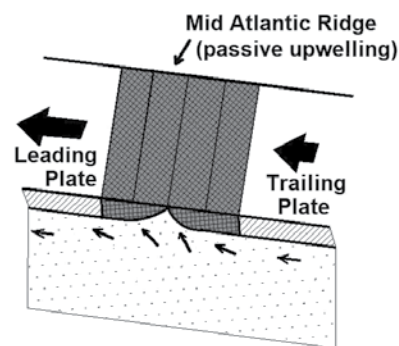


Figure 1. The motion of the ocean floor is greater west of the Mid-Atlantic Ridge, while the ridge itself moves westward. If we use the convention that the African Plate is stationary, then the arrow showing the plate velocity east of the ridge should be zero, but Pavoni did not follow that convention in his Fig. 6b. Drawing by Chaffin, after Pavoni (1993), Figure 6b.

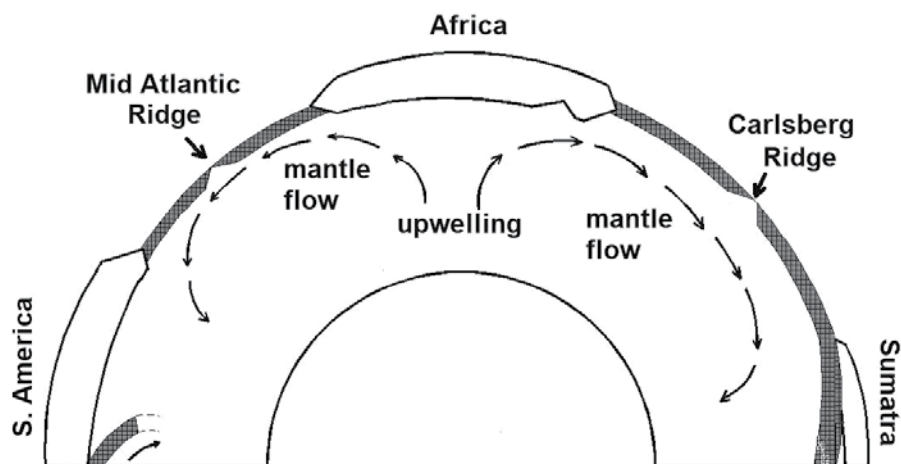


Figure 2. Unidirectional, horizontal flow in the upper mantle beneath the active, mid-oceanic ridges (Mid-Atlantic and Carlsberg) and large-scale upwelling in the mantle below Africa. Drawing by Chaffin drawn after Pavoni, figure 7b.

“Part of the answer is that both North and South America have moved in a dramatic manner to the west as a consequence of the large amount of subduction that has taken place on their western margins. In response to this westward motion of the Americas, the spreading ridge centered in the Atlantic has migrated westward relative to Africa.”

Thus, while Baumgardner’s three dimensional computer simulations have successfully shown the breakup of Pangaea (Baumgardner, 1994, 2003), the plate motions surrounding Africa have never been a great mystery. Baumgardner’s results thus are a credit to creation modelling.

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A Discontinuous Change in Half-Life Seems to Characterize Many Findings Regarding Accelerated Decay

When we consider the accelerated decay hypothesis (Vardiman, Snelling and Chaffin, 2005), one naturally wonders whether a simple function might exist, derivable from a hypothetical mechanism for the change in decay rates, which would convert isochron ages into actual ages. For example, Froede and Akridge (2012, p. 58), wrote: "This also raises the question of a quantifiable conversion factor for each radiometric method; such numerical factors would be invaluable for creationist analyses of radiometric age-dates."

Although Humphreys (2012) provided a very effective response to the criticisms of Froede and Akridge, there is an aspect that could use clarification. In this letter it will be shown some various possible mechanisms for accelerated decay lead to the same result: the behavior of the half-life during the accelerated decay is more like a step function, sometimes compared to the postage stamp function for different weights of the letter. The US postage changes suddenly when the letter weighs more than one ounce, currently rising from 55 cents to 70 cents, then to 85 cents for letters greater than two ounces. Similarly, the half-life is not what calculus books (for example, Bradley and Smith 1995, p. 57) call a continuous function, since the value changes at some point. C-14 behavior may perhaps be an exception, due to the large nuclear level spacing in this nucleus and the lack of a pairing gap (Chaffin, 2012, p. 206; Chaffin, 2008, pp. 185–186).

In Chapter 7 of RATE, volume 2 (Chaffin, 2005a), quantum mechanical calculations were presented for an alpha particle in a nucleus. In quantum mechanics, the wavefunction is a quantity whose square gives the probability density for finding the particle, the alpha particle in this case. The calculations showed that, if the strength of the

strong nuclear force were to change, the number of nodes in the effective wave function could change suddenly (Figures 1–3). This results in a jump in the decay constant (which is 0.693 divided by the half-life, and also the fraction of the nuclei decaying per unit time) as illustrated in Figure 3. Thus, the decay rate is not a continuous function of the strong nuclear force strength, and hence not a continuous function of time should the strong nuclear force strength change.

Similarly, Oliver and Chaffin (2012, p. 206), in their paper discussing the possible effect on nuclei of an upsurge of magnetic monopoles, out of the earth's interior, wrote: "When a monopole approaches a nucleus, it can lead to a way to bypass the normal routes for the transitions involved. The monopole induces the nucleus to transition to an excited state with a different spin and parity than the ground state, which then has a larger probability of beta decay." This theory

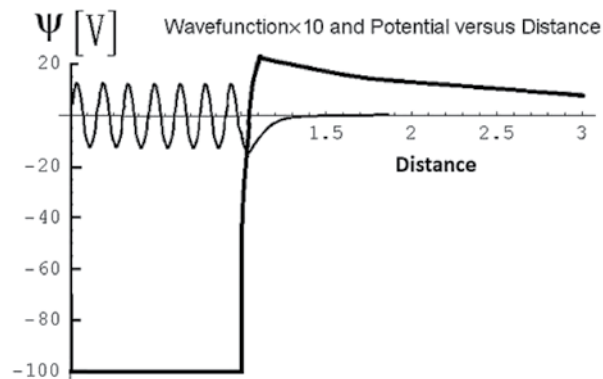


Figure 1. The exponentially diffuse boundary potential and the corresponding wavefunction versus distance. The nonzero wavefunction outside the boundary of the nucleus indicates escape probability. For details see Chaffin (2005a).

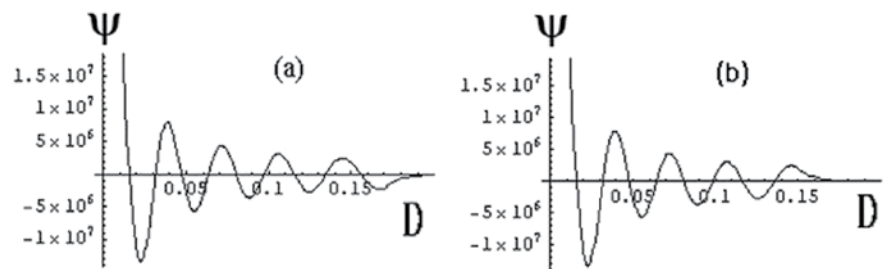


Figure 2. Sudden change in the number of wavefunction nodes. The wavefunction for well depths of 58 MeV (a) and 54 MeV (b). The x-axis is the radial coordinate D of the alpha particle., Figure 2a shows the wave function for a well depth of 58 MeV. Figure 2b shows what happens when the well depth is changed to 54 MeV, without changing the alpha particle energy. If one counts the number of nodes in Figure 2a, there are nine, not counting the ones at zero and infinity. For Figure 2b, there are eight nodes, a reduction by one. See Chaffin (2005b) for details.

thus also yields a decay rate that is not a continuous function of time.

In Chaffin (2017), it was shown that, as a result of a nearby supernova, and the change in the hypothetical *acceleron* field, the mass of the U-238 nucleus could change, resulting in beta-minus decay, instead of alpha decay, becoming the predominant mode of decay. The consequent drastic change in nuclear half-life is another example of a discontinuous change with time.

Froede and Akridge (2012, p. 58), raised the question: “If accelerated decay occurred, why were short-lived isotopes such as ^{14}C not eliminated altogether?”

In Chaffin (2008), the dependence of nuclear pairing phases on the strength of the nuclear force were discussed. For some nuclei it was shown that a slight change in nuclear force strength could cause a discontinuous change in half-life. For other nuclei, such as C-14, this was shown not to be the case (Figures 4, 5). For C-14, the half-life is not as drasti-

cally altered as in those cases in which a step function type change occurs.

Baumgardner had already provided an answer to the Froede and Akridge question (Baumgardner, 2005, p.620): “Accordingly, we here offer the tentative hypothesis that, whatever the physics was describing the decay acceleration, it did not operate in so simple a manner as to reduce temporarily the effective half-lives of all radioisotopes by the same factor.”

Thus, Chaffin (2008) provided an example of how Baumgardner’s reasoning might be realized. Of course, the actual mechanism for accelerated decay still remains a subject for research; the mechanisms already studied may or may not be the correct ones.

Empirical studies such as those presented in Vardiman, Snelling and Chaffin (2005) could potentially provide a conversion between actual dates, consistent with Biblical history, and isochron ages. However, for this to be

worked out it would require the use of rock and mineral samples which had not been appreciably disturbed, and it would be very difficult to achieve in practice. As we have seen above, the discontinuous changes in half-lives that could be expected for most isotopes also make it appear unlikely that theory would provide such a simple conversion function such as Froede and Akridge desired. An exception to this difficulty might be C-14 studies.

C-14 is exceptional in that there may be no pairing (Figure 4), hence when the nuclear force strength changes, no phase change of the nucleus occurs. Alternatively, should the Oliver and Chaffin (2012) scenario of magnetic monopole scattering be the applicable theory, the excited states of C-14 are at such high values that discontinuous change in half-life does not occur. According to Negret et al. (2006), the first excited state of C-14 is at 6.1 MeV. The monopole scattering cannot induce the nucleus to transition to an excited state of C-14 since the energy level of the excited state is too high to be reached. For C-14 a smooth or continuous function may exist relating half-life to time during the accelerated decay episode.

But in this discussion it is important to keep the bigger picture in view. According to the Biblical text, the Flood, as measured by the time Noah and his family were aboard the ark, lasted a year and ten days. The amount of nuclear decay daughter products in igneous rocks erupted approximately coincident with the Great Unconformity, which many young-earth creationists identify as marking the Flood’s onset, is on the order of 600 million years, at today’s measured rates of decay.

Although there is not consensus as to the point in the rock record that marks the Flood’s end, this author sides with those who place the Flood’s termination after the vast amount of sediment deposition on the continental shelves that logically appears to represent the

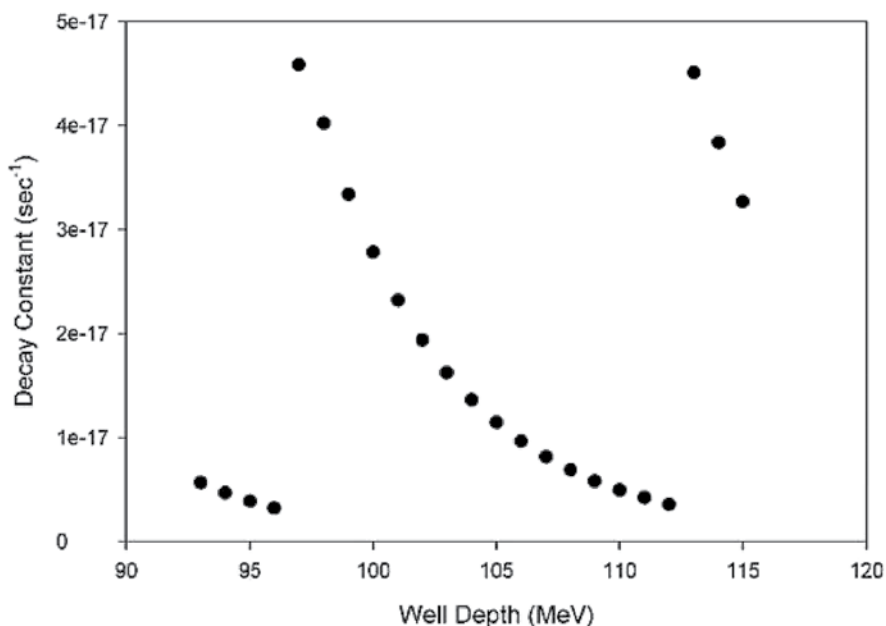


Figure 3. The decay constant (sec^{-1}) versus the well depth of the alpha particle (MeV). The decay constant is the fraction of the nuclei decaying per unit time. As the number of nodes in the wavefunction changes, the decay constant undergoes a discontinuous change. For details see Chaffin (2005a,b).

run-off from the cataclysm. Igneous rocks erupted at this place in the record contain of the order of 3–5 million years' worth, at today's measured rates of decay, of nuclear decay daughter products.

This implies that on the order of 600 million years' worth of nuclear decay

must have occurred during the span of only approximately a single year of the Flood. That in turn means that the *average* rates of nuclear decay during the Flood were *roughly 600 million times higher* than they are measured to be today. A detailed time history of the

manner in which decay rates themselves may have varied during that brief interval would not change this conclusion.

At this early stage in our understanding of these matters, an adequate approximation of the decay rate versus time history for the long half-life isotopes would seem to be simply a pulse a year in duration, coincident with the Flood, with an constant amplitude 600 million times the values measured for the half-lives today. This approximation, of course, would not apply to radioisotopes like C-14.

It is worthwhile to emphasize that in a rock/mineral which can be approximated reasonably well as a closed system, stable nuclear decay daughter products accumulate in a simple manner rather than decrease. For igneous rocks for which this approximation holds, the relative amounts of accumulated daughter products can be utilized to obtain reliable relative ages for such rocks. For most applications in Flood geology, it is the relative age, and not the day and hour from the onset of the Flood, that is the primary concern.

Whitelaw (1970, 1975, 1993) made good progress towards specifying a conversion from C-14 age to actual historical age, consistent with Biblical clues. After examining the basic assumptions of Carbon-14 dating, Whitelaw attempted to give a reconstruction of Biblical chronology based on Carbon-14 dates of historical artifacts, with creation around 7000 years ago followed by a worldwide Flood about 5000 years ago. On the basis of thousands of published radiocarbon dates, he gave tables and graphs showing true age versus published age. Brown (1992, 2006) made a similar study, initially restricting the treatment to post Flood dates, with the Flood tentatively set at 5350 years before the present. Brown's 2006 update discussed pre-Flood C-14 levels and their influence on the resulting dates.

Understanding the detailed mechanism of accelerated decay is an impor-

Pairing Gap vs Pairing Strength for C-14

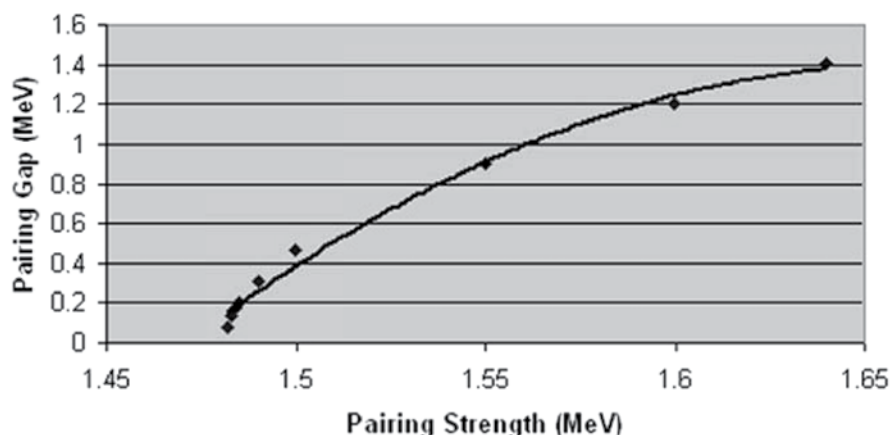


Figure 4. Pairing gap versus pairing strength for ^{14}C . As indicated, no pairing gap exists for ^{14}C for a pairing strength below about 1.48 MeV. The expected pairing strength in a such a light nucleus is less than 1.48 MeV. For details see Chaffin (2008).

Pairing Gap vs Pairing Strength for Os-187

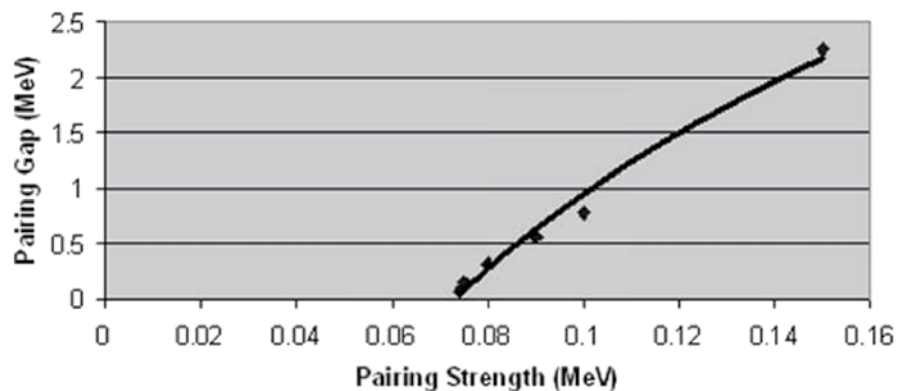


Figure 5. Pairing gap versus pairing strength for ^{187}Os . For this nucleus, the data indicate that a nonzero pairing gap should exist for this nucleus, since the pairing strength for a nucleus of this size is more than the value where the x-axis is intercepted. For details see Chaffin (2008).

tant topic for research. History of science includes numerous examples where understanding a mechanism led to progress. As one example, Johannes Kepler understood in the early 1600's that the planets follow elliptical orbits. However, the use of these orbits to predict comet appearances and eclipses did not succeed in much precision until the law of gravity was formulated by Isaac Newton (Tiner, 1975, pages 99–111).

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Metaphysical Form in Biblical Creation Science

The meaning of “metaphysical form,” put most simply, pertains to the ideas of all things in the mind of the Creator, prior to their actual creation in space-time. The “intelligent design” that can be formally detected by methods developed by Dembski (2004) represents the effect in matter-energy of a corresponding metaphysical form in the infinite intellect of the Intelligent Designer. The relation between metaphysical form and intelligent design is formal causation. It occurs to this writer that consideration of formal causation by metaphysical form, of ordered structures of matter-energy in space-time, might open new possibilities for biblical-creationist theory.

Any created being can be considered metaphysically in two aspects: its *esse* or actual being (*that* it exists) and its *essence* or nature (*what kind* of being it is). Its essence, in turn, consists of matter and form. In other words, the Creator in creating a creature knows what kind of creature He is creating, both formally and materially; and by knowing it as created He endows it with being, causing it to be (Geisler, 2003).

Say He is creating a star. He knows its essentially concentric, spherical form as a balance of gravitation and radiation (this is the “missing link” in secular star-formation theory); and He knows the proportions of the chemical elements He desires, both initially and after development in time. The Creator’s knowledge also comprises the geometries of space-time whose curvature correlates with local density of matter-energy; and not just their intellectual forms but also their densifications of matter-energy as the geometry turns physical. This is the firmament created on Day 2 (Humphreys, 1994), and its expansion, further curvature, etc., is subject to divine control by judicious adjustment of variables and tweaking of “constants,” in a real cosmological geometry. Human geometric construc-

tions can only approximate this actual geometry enjoined by God.

Say He is creating a planet, Earth for example. His knowledge of its internally differentiated spherical form and its exact elemental composition actually nucleates the hypergeometric curvature in space-time, providing the necessary density of matter-energy for the planetary body to exist. He also knows the quantitative mass of this celestial body as part of its essence, as likewise in the case of a star. The planetary essence, endowed with being (*esse*) by the Creator originates as an inchoate orb of chemical matter (Day 1) which quickly, beneath the undivided waters, assumes geological form prior to the continental uplift (Day 3). Now suppose that God’s knowledge of the Earth as created includes a perspective in spherical coordinates centered on the core, with radial axes extending to every point on the planetary surface, and several geophysical functions operative in the radial direction. These functions could include a thermal vector inducing the rise of magma along any radial axis toward the surface, and a differential-vertical vector inducing uplift/subsidence along lines on the surface formed by intersections of activated vectors.

Now say He is creating a living being, or life-form. In this case the formal aspect of the essence is largely encoded in its DNA, already material, which directs the synthesis of the proteins of which its body is metabolically built, along with myriads of other proteins with all sorts of functions in the organism. DNA also regulates biochemical processes in networks across space-time, coordinating sequences of biochemical events in ensembles of correlations—all in the knowledge of God. And what God knows to be real, is real. Subtly subtending this miniature space-time geometry of biochemical processes is a morphogenetic field shaping the body “according to its

kind,” which is probably related to the breath of life which animates a living being. God know it and it is.

The preceding discourse is of course not scientific, except in the sense that metaphysics is also a science. But it seems to the writer that biblical creationist theory, which deals scientifically with the natural effects of a supernatural Creator and Lord, ought to be equipped with concepts representing divine causal action. Molen (1994) has rightly cautioned about too readily “introducing fiat interventions from God” to save hypotheses from evidential “gaps,” even mentioning accelerated radioactive decay as an example, and adding, “we are not supposed to believe in a ‘God of the Gaps,’ but in the ‘God of the Knowledge.’” But Genesis says, “God created the heavens and the earth,” and also states unequivocally that He caused the Flood. Although the biblical sciences of nature devote most of their study to created processes and the created laws that govern them, is there not room for a formalism representing direct divine action on matter-energy in space-time, in those events (like Creation and the Flood) where Scripture clearly reveals it?

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Detection of Design in Astronomy?

Danny Faulkner in particular has been calling for better understanding of how the notion of design might apply in astronomy. This note offers a few reflections on some astronomical observations in light of Dembski's (2004) approach to detection of intelligent design, as a small contribution to this effort. In *The Design Revolution*, Dembski (2004) refers to the observable characteristic implying intelligent design as *specified complexity*: "The *complexity in specified complexity* refers to improbability." Thus the first criterion to be met by an object or domain as implying design is that it display a structure or pattern that is improbably complex, or to put it differently, the probability of whose occurrence is very low because of its degree of complexity. The second criterion concerns the notion of specification:

The patterns that in the presence of complexity or improbability implicate a designing intelligence must be independent of the event whose design is in question. Crucial here is that patterns not be artificially imposed on events after the fact. ... A pattern is conditionally independent of an event if adding our knowledge of the pattern to a chance hypothesis does not alter the event's probability under that hypothesis. The *specified* in *specified complexity* refers to such conditionally independent patterns. (Dembski, 2004)

Let's unpack this notion of specification by applying it to an example: the super-galactic macrostructure of the observable astronomical universe, in relation to the big-bang hypothesis of its origin, and to a spherical geometry centered on Earth. The celestial macrostructure revealed by deep-space surveys includes a phenomenon known to astronomers as "fingers of God," namely a significant proportion of galactic superclusters, linear in form and pointing from all directions right toward

(and away from) Earth (Matthews, 2008.) Now our knowledge of this observed pattern, apparently informed by geocentric radial coordinates, does not alter the (very low) probability of its occurrence under the "chance hypothesis" or big-bang scenario. At the same time this observed pattern fits the scenario of the firmament of outer space-time being stretched out from Earth in all directions by God's creative Intelligence. The radial pattern of the observed radial superclusters is not "artificially imposed after the fact," it is simply what we observe. Can we then claim that the "fingers of God" exhibit specified complexity, and therefore intelligent design?

Dembski (2004) also approaches the definition of intelligent design from the standpoint of information theory: "Specified complexity is a binary form of information ... (and) depends on a dual reduction of possibilities, a conceptual reduction (i.e. conceptual information) combined with a physical reduction (i.e. physical information). Moreover, these dual reductions must be coordinated so that the physical information matches the pattern set by the conceptual information." Let's examine this approach with another astronomical example: the triple correlation between Earth's orbital plane and the fine structure of the cosmic microwave background (CMB). When examined for extremely fine differences in temperature, The CMB is warmer in one half of our sky than in its opposite (temperature dipole), showing more temperature variation in a different half of the sky (perpendicular to the first) than in its opposite; and displays a quadrupole/octupole plane (perpendicular to the other two) which intersects the solstice points on Earth's orbit! "Earth lies at the intersection of all three of these major CMB defined features" (Matthews, 2008).

These observable features reduce the physical possibilities for tempera-

ture distribution in the CMB, from the original measurements of gross uniformity (Penzias and Wilson) to a complex polarity (dipole, quadrupole, and octupole) when measured finely. Thus the physical information acquires complexity. Conceptually, the notion that the CMB is the signature of a "big bang" from which the universe arose is reduced by the remarkable correlation just noted, to a concept of the CMB (and its origin) involving formal alignment of Earth's orbit with the CMB's fine structure. Thus the conceptual information acquires specificity, and matches the complex physical information; which makes this a case of specified complexity and therefore of intelligent design—does it not?

In both of these examples the affirmation of design was followed by a question mark, since the writer is not entirely certain he has correctly applied Dembski's (2004) terminology in these cases, and has not asked the latter to review their application. At this point, they are simply speculations designed to introduce Dembskian methods to the discourse of creation astronomers, and to the writer's best knowledge, they are not currently under discussion. And it is possible they will inspire further work (in much greater detail) along similar lines, including the role of metaphysical form in the original nucleation of stars and galaxies.

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Context Matters: Comment

While I am grateful for the good contributions Jake Hebert has made to young-earth science, I must strongly protest the eisegesis in his most recent article (Hebert & Johnson, 2018). Indeed, Hebert's previous CRSQ article (2017) raised similar concerns, some of which Nick Sabato (2018) has already voiced. Unlike Sabato, however, I attribute these articles' faulty hermeneutic not to any particular eschatological scheme but rather to a failure to properly acknowledge context.

The primacy of context is a standard—and fundamental—principle of hermeneutics. In the words of Klein et al. (2004), “the correct interpretation of Scripture is the meaning *required by the normal meaning of the words in the context* in which they occur” [emphasis added]. Hebert and Johnson's interpretation of Psalm 29:10 and Isaiah 40:22 necessitates nonstandard referents for the words מַבְבֹּל (*mabbûl*) and חֹג (*hûg*), respectively. Their interpretation is thus valid only if the context requires these (extremely) nonstandard meanings.

Let us first consider Psalm 29:10. As Hebert and Johnson note, every other occurrence of *mabbûl* in Scripture refers to the Noachian Deluge. Given this fact, does the context provide any indication that in this case, *mabbûl* refers instead to a sphere of water billions of light years distant (and considered by the authors to be the “floor” of heaven)? The context instead identifies specific *terrestrial* geography—Lebanon (vv. 5–6), Sirion (i.e., Mt. Hermon, in v. 6), and Kadesh (v. 8)—all known locations in the Middle East. Verse 9 adds deer and forests to the terrestrial references. And in this Middle Eastern setting (complete with deer and forests) the psalm describes a mighty thunderstorm (poetically called “the voice of the LORD”) which breaks the cedars, shakes the ground, shoots out divided flames of fire (lightning), and strips the forests bare. It is in this

context that the Psalmist refers to the *mabbûl*. The context thus allows two options for understanding the word: *mabbûl* could refer to the thunderstorm itself, which in this case would be a sort of “mini-*mabbûl*”; or, more probably, *mabbûl* could allude to the flood of Noah, of which the thunderstorm is a feeble echo. (See also the corresponding entry in Brown-Driver-Briggs.) Either of these two options fits the context. But the context gives absolutely no indication that the Psalmist is suddenly referring to a “flood” billions of light years distant, namely, the “waters above.” To reiterate, the correct interpretation depends on the normal meaning of the words in context, and the “waters above” simply are not in view here.

We next consider Isaiah 40:22, which mentions the “circle (*hûg*) of the earth.” Hebert and Johnson contend that *hûg* actually refers to the “dance” of the earth's orbit about the sun combined with its rotational motion. To support this completely unprecedented interpretation, Hebert and Johnson appeal not to the context of this verse but rather to other usages of *hûg* and to the meanings of similar Hebrew words. In particular, they observe that *hûg* (as either a noun or a verb) can appear in contexts of motion and that etymologically related words include aspects of celebration and dance.

Interestingly, it is simple to manipulate the English language in precisely the same way: we could note that my dinner plate is a circle; that the noun “circle” can have connotations of motion (“we walked in circles”); that the verb form of “circle” has definite connotations of motion (“the airplane circled the landing strip”); that related words (circulate, circuit) imply motion in a closed path; and that at least one of these related phrases (Cirque du Soleil) implies dancing—and thus we might conclude that my dinner plate dances. Except that this procedure is sheer

nonsense. And it is nonsense whether we perform it in English or in Hebrew. Nor does use of the term “philological” make it any more acceptable. Because as always, it is the usage of the word in context that determines its meaning. And there is no hint of terrestrial motion (much less dancing) in Isaiah 40; rather, the entire point of the passage is the insignificance of the earth—and indeed of all things—compared to the transcendence of God.

Readers unsure of the above can perform a simple test: take a Bible (any standard translation will work) and read through Isaiah 40. Then ask yourself if the passage (apart from the word under consideration) provides any hint that the earth is spinning or orbiting (or dancing). And then read Psalm 29, and ask yourself: is the Psalmist describing an earthbound storm or a sphere of water billions of light years distant? The results of this exercise will speak for themselves: Hebert and Johnson's interpretations are not derived from the text (exegesis) but imposed upon the text (eisegesis).

Why does this matter? First, a journal like CRSQ deals by design with a variety of quite technical issues. If readers find that they cannot trust the journal authors' exegesis of Scripture (which they can check by reading the context for themselves), then how can the readers trust the authors when they deal with scientific matters (which many readers cannot check for themselves)? Creation science requires exegesis rather than eisegesis. But second—and of supreme importance: the Bible is the Word of the living God. If we twist it, we do so to our own destruction (2 Peter 3:16). If on the other hand we revere our Creator, who breathed out this Word, then we will exercise the utmost care to handle it correctly (2 Timothy 2:15).

It is commendable that Hebert and Johnson give close attention to the very words of Scripture, but even the best

intentions cannot justify a flawed hermeneutic. Brethren, we can and must do better.

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Maxwell Lorentz

Reply to “Context Matters”

We are grateful for the feedback we have received in response to our two *CRSQ* articles (Hebert 2017, Hebert and Johnson 2018), even if some of that response has been negative. Before addressing the specific concerns in this most recent letter, it might help to step back and look at the big picture.

It appears that most creationists have (finally!) accepted Russ Humphrey’s arguments that the “waters above” are in deep space, far beyond the most distant galaxies (Humphreys 1994a,b). Note, however, that we are not advocating “consensus science” as a proper methodology (Guliuzza 2009). Regardless of the concept’s popularity, the Scriptures seem to *demand* this understanding, since the stars and other heavenly bodies are said to be “in” the expanse between the waters (Genesis 1:15). Furthermore, Psalm 148:4 tells us that “waters above the heavens” were still in existence at the time this psalm was written, long *after* the Noachian Flood.

This immediately invites the question, Is there something on the other side of the waters? Could that “something” be Heaven itself, the abode of God? Creationists have generally been somewhat hesitant to affirm this, but let us briefly

consider some Scriptural evidence for this possibility.

In Isaiah 14:13, Lucifer boasts, “I will ascend into heaven, I will exalt my throne above the stars of God.” Lucifer is seeking to usurp God’s throne, to “be like the most High” (Isaiah 14:14). But in order to do so, he has to exalt *his* throne (in place of God’s throne) “above the stars of God.” If God’s abode is directly on the other side of the heavenly waters, then this statement is *literally true*. God’s throne is literally *above* the stars!

There are multiple places in Scripture that speak of heaven as being *above* us. For instance, Galatians 4:26 says that the heavenly Jerusalem is “above.” We are told in Colossians 3:1, “If ye be risen with Christ, seek those things which are above, where Christ sitteth on the right hand of God.” Is the word *above* merely metaphorical? We don’t think so. We know that Christ is *literally* sitting on “the right hand of God.” According to this verse, He is doing so “above” us!

Moreover, Christ ascended “up far above all heavens” (Ephesians 4:10). If we take this literally, it would imply that Christ ascended above both the atmospheric and celestial heavens. In other words, Heaven is *above* us.

Likewise, Revelation 4:6 mentions a “sea of glass like unto crystal” before God’s throne. Could this be an allusion to the heavenly waters? And where did this idea of a “celestial ocean,” found in so many ancient cultures, originate (Dillow 1982)? It could *not* have come from observation, since we can’t *see* the ocean. The logical explanation is that these cultures retained a memory of this celestial ocean passed down from Adam and his descendants, who in turn received the idea from Genesis 1!

So with this background in mind, let us return to Psalm 29, which could (and probably is) describing a thunderstorm, among other things. But the psalm describes God’s sovereign rule over the storm. That in turn immediately raises the question, from *where* is God ruling over the storm?

Dr. Lorentz is arguing, as one of two options, that the “flood” (*mabbûl*) of verse 10 could be the thunderstorm itself (which he labels “a mini-*mabbûl*”). But that seems to suggest that God is sitting enthroned directly upon the thunderstorm itself, i.e., upon the mixed mass of turbulent air, rainwater, and lightning bolt discharges. However, note that the second half of verse 10 says “the LORD

sitteth King for ever.” In other words, God’s “sitting” seems to be permanent (“for ever”). The parallelism of Hebrew poetry (Johnson 2011) would seem to suggest (though perhaps not demand) that the LORD’s sitting upon the flood is *also* permanent. Yet, thunderstorms are temporal and transient; they quickly disappear. However, if the flood is indeed a heavenly ocean that *permanently* marks the boundary between our universe and Heaven, then this parallelism makes good sense.

Furthermore, there are other aspects of this psalm that seem to describe God’s heavenly court. God’s “temple” (*hêkâl*, which can also be translated “palace”) is mentioned in verse 9. Is God is holding court directly on top of the thunderstorm, or from Heaven itself?

Dr. Lorentz suggests that the more likely “option,” for the meaning of *mab-bûl* in Psalm 29:10, is the Noachian Deluge (of Genesis 6–9), based upon the context-marking elements of terrestrial geography (e.g., Lebanon), as well as the mention of terrestrial lifeforms (e.g., deer, forests). True enough, those are terrestrial referents. However, there is another option (for these context-marking items): God’s entire universe. Psalm 29 not only refers to elements of Earth (e.g., Lebanon’s cedars, Kadesh’s wilderness), it refers to *benê-’êlîm* (which is likely a reference to angels).

In other words, because Psalm 29 emphasizes God’s sovereignty over all His creation, allusions to terrestrial elements do not *per se* eliminate the created universe as the overarching context of Psalm 29. Likewise, the reference (in Psalm 29:3) to “waters” cannot *per se* require a terrestrial-only context, because “waters” are introduced, in Genesis chapter 1, as a fundamental substance that God created and worked with during the cosmic context of Creation

Week, especially Day 1 (1:2), Day 2 (1:6; 1:7), and Day 3 (1:9; 1:10).

Understand that we are not basing our entire argument on *just* Psalm 29. But we are asking creationists to look at the Scriptural evidence as a whole. The idea that the “waters above” separate our universe from God’s abode seems to “flow” (no pun intended!) very naturally from the Scriptural evidence. Given the considerations above, it seems perfectly reasonable that the “flood” of verse 10 could be a celestial ocean, especially given the reference to angels in verse 1 and a “temple” in verse 9.

Regarding Isaiah 40:22, we disagree that “the entire point of the passage is the insignificance of the earth—and indeed of all things—compared to the transcendence of God.” That idea is but one point provided within Isaiah 40:22, yet God has informed us of much *more* beside that one point. Furthermore, that still doesn’t tell us what the “circle” (*hûg*) in this verse is. Regardless of whether it refers to the sphericity of the earth or the earth’s orbit, the fact that the LORD sits enthroned above it does indeed remind us of our insignificance!

But the more critical question for understanding the intended meaning of Isaiah 40:22 is this: if this verse is describing the Earth’s sphericity, why did God not steer Isaiah to here use the Hebrew word for *ball*, as he did in Isaiah 22:18? Likewise, why is it that in the only other two places that this Hebrew noun is used in the Old Testament (Job 22:14 and Proverbs 8:27), the word “circle” or “circuit” is a much better fit than “ball”?

Let us remember that, if the “waters above” are indeed an interface between our universe and Heaven itself, this could potentially have profound implications for cosmology. We know that God finished his work of creation by the end of Day 6 of the Creation Week. This

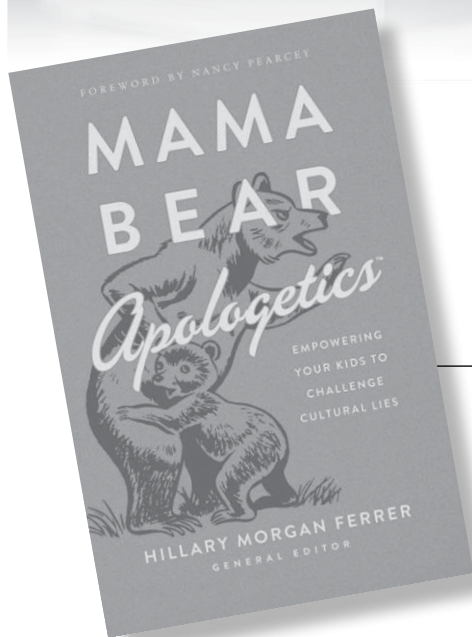
means that (with the possible exception of the occasional miracle) he is no longer creating mass/energy. But since the “waters above” are arguably part of our universe, this means that the mass of those waters cannot increase, either. But if the universe is expanding, then the waters must presumably expand with it, implying that the waters will eventually become so thin that the “sea” disappears. If God intended these waters to be a (presumably permanent) boundary between our universe and Heaven, would He desire the waters to thin so much that they eventually disappear? Is this Scriptural evidence against an expanding universe?

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Media Reviews



Mama Bear Apologetics

edited by
Hillary Morgan Ferrer

Harvest House Publishers,
Eugene, OR, 2019,
288 pages, \$17.00

The book's unusual title comes from a female bear's ferocious protection of her young. Seven mothers, all women of faith and tenacious defenders of children, contributed to chapter topics. These moms have "had it" with the cultural nonsense which surrounds us today. They skillfully expose the influence and untruths of naturalism, postmodernism, extreme feminism, Marxism, hyper-skepticism, socialism, religious pluralism, miss-directed social justice, progressive Christianity and much more.

Nancy Pearcey, an accomplished defender of biblical truth, provides the Foreward. She believes parents are the most important apologists our kids will ever know and she recommends the book for making apologetics clear and accessible to ordinary parents (p. 12).

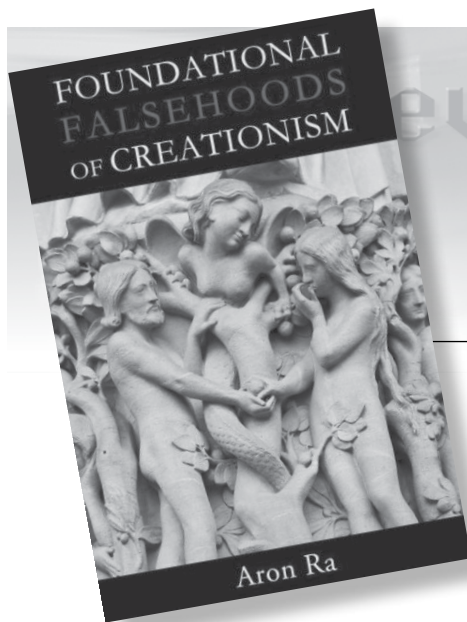
Editor Hillary Ferrer founded the ministry Mama Bear Apologetics. Biology training gives her a special interest in the weaknesses of evolution and naturalism. Hillary's website, mamabearapologetics.com, offers many helpful articles and podcasts.

Although addressed to everyday parents, the book is far from simplistic. Instead, it is a refreshing approach to a clear defense of Christian faith in our secular world. The following quotes illustrate the authors' lively approach to issues. "The number of self-help books...

is evidence enough that self-helpism fails. If it truly worked, you would only see one" (p. 93). "We are out to demolish ideas, not people" (p. 230). "Mess with my kids and I will demolish your arguments" (back cover).

The theme of the book is to raise our children to be critical thinkers. They need to be encouraged to "chew on ideas and spit out those that are unhealthy." Said another way, our kids cannot avoid "breathing" the surrounding culture but they need discernment in rejecting unhealthy air (p. 18). The writers of this book are serious about training the next generation. It is refreshing to know that a host of moms cares deeply about the coming generation.

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Foundational Falsehoods of Creationism

by Aron Ra

Pitchstone Publishing, Durham, NC, 2016, 440 pages, \$18.00

The author is president of Atheists Alliance of America, an organization formed to use the American legal system to pressure local, state, and federal government officials to comply with their interpretation of the separation of religion from government. This anticreation book attempts to cover in detail some of the main claims made by creationists.

Insight into the author's motivation for the book is provided on page 227: "My wife, a former old-earth creationist Christian schoolteacher [has] now turned atheist activist science teacher" to help her students see the light. Ra is active in writing and speaking against creationists of all stripes, from young earth to intelligent design.

A chapter of particular interest to me was the one on mutations. Ra claims that Darwin doubters, persons he collectively calls creationists, believe "there are no beneficial mutations" (p. 211). Depending on how you define the word "mutation," informed creationists do not claim there are no beneficial mutations, only that they are rare and that very few are useful to achieve what Darwinism requires.

Ra quotes one expert who gives a number estimate of 1 in 150 newly arising mutations that are beneficial (p.

216). This is also a common estimate I have come across in both creation and evolutionary literature. The estimate Ra cites, however, disproves the chapter conclusion, namely, that mutations are relatively common and produce the genetic variation necessary for improved chances of survival in a specific environment compared to similar life-forms lacking the advantage. The 1:150 ratio translates into 149 deleterious or near neutral mutations out of 150. In time, the near neutral mutations add up, eventually causing genetic meltdown and death while only 1 of the 150 is beneficial.

Dawkins' *Climbing Mount Improbable* (1996) compares evolution to climbing up a mountain. To evolve rapidly from an amoeba to a human, he admits, will not happen, just as walking vertically straight up the side of a steep mountain is very difficult for most people. Likewise, if evolution progresses very gradually, as Darwin proposed, the analogy is like a man traveling largely horizontally on switchbacks and gradually working his way up the mountain. Given the mutation ratio of 1:150 that Ra proposes for every step forward, the mountain climber will travel 149 steps backward. In short, the climber will never make it up the mountain but will continually fall back away from the base of the mountain.

When it was assumed that 99% of human DNA was junk, evolutionists argued these vast stretches could absorb many of the 149 near neutral and deleterious mutations without causing genetic catastrophe. When the *Encyclopedia of*

DNA Elements (ENCODE) research documented that over 80 percent of the so-called junk DNA have important regulatory functions, this explanation (of huge stretches that could absorb many defective, or flawed, mutations) was falsified.

Furthermore, the list of putative mutations Ra provides to prove that mutations can provide the raw material for evolution (p. 216) in most cases does not add complexity or help to evolve the organism. Rather, the so-called mutations are due to design, such as inbuilt systems that can provide some flexibility to the organism. An example Ra cites is the CCR5-delta 32 mutation, which protects the person with the mutation from AIDS (p. 218). This illustrates what many, if not most, so-called beneficial mutations actually do.

The CCR5 receptor is required for HIV-1 virus entry into the cell. The HIV-1 virus is the main virus that causes AIDS. In short, if the CCR5 gene is mutated, the AIDS virus is unable to enter the white blood cells called T-cells, thus the person with the mutated gene is immune to AIDS. The specific mutation in the gene (CCR5 Δ 32) is inherited, and this confers innate resistance to HIV-1. The CCR5 Δ 32 mutation is a 32-base-pair deletion (Δ means deletion) that introduces a premature stop codon into the CCR5 receptor locus, breaking it, resulting in a nonfunctional receptor. Without the CCR5, HIV cannot enter the cell.

As Michael Behe notes, this mutation effect does not result in a new and improved gene, but a broken gene that

does not do what the gene was designed to do, namely in this case serve regulatory functions (Behe, 2019). As Behe concludes in his *First Rule of Adaptive Evolution*, the mutation breaks or blunts any gene whose loss *increases* the number of offspring. The fact is, the overwhelming tendency of random mutations is to *degrade* genes, and that degradation can occasionally be helpful, such as in the HIV example noted above. Natural selection itself acts as a powerful de-evolutionary force, *increasing* the number of broken and degraded genes that turn out to be helpful to survival in the population (Behe, 2019).

Another problem is that every cell has many built-in complex repair mechanisms designed to identify and eliminate, not just mutations, but also misfolded and unassembled proteins (Bergman, 2005). Most of the other examples Ra cites are similar, and none helps evolution by producing new structures or organisms.

Ra discusses the so-called nylon-eating gene mutation in a strain of *Flavobacterium*. It is assumed to be a mutation because these bacteria can produce enzymes that allow them to feed on certain by-products of nylon chemical synthesis that are assumed not to have existed prior to the invention of nylon in the 1930s. Three enzymes (E-I, E-II, and E-III) are able to hydrolyze various amide bonds found in the nylon-6 synthesis waste substances. Amide bonds are commonly used in both many natural and man-made organic products. Many of the nutrients required by complex organisms are the break-down products of enzymes present only in bacteria (Truman, 2015).

Without recycling organic matter back to raw materials, most of earth's usable sources of carbon, nitrogen, and oxygen would soon be depleted. This recycling function is a central role of bacteria. Bacteria are designed to have enzyme flexibility to break the bonds of compounds that are slightly different

from those found in nature to allow them to break the bonds of almost every known organic compound, both those existing and similar bonds that do not currently exist. The nylon-eating bacteria by-products are only one of almost endless examples of this ability.

Another example Ra gives is that vestigial organs are another proof of evolution. For example, Ra quoted Ken Ham as stating the belief that "wisdom teeth are evidence of evolution" is "ridiculous, outdated, and false." (p. 227). Ra then argues that human "dental arches have been reduced over hominid evolution" and, as a result, have been shown by researchers to produce problems due to human smaller jaws. Ra claims that the rate of impaction is close to a whopping 85 percent, a number for which he does not cite a single authoritative peer reviewed reference in support. I have been surveying college health science students on this issue for over a decade, revealing that the vast majority still have their 3rd molars. The average age of our students is 28, and very few are teenagers.

The current estimate is that less than "12% of impacted teeth have associated pathology. This incidence is the same as for appendicitis (10%) and cholecystitis (12%), yet prophylactic appendectomies and cholecystectomies are not the standard of care for these conditions for good reason, and should not be for wisdom teeth either (Friedman, 2007, p. 1554). In support of this study, "evidence is mounting that routine wisdom teeth removal" is a medical problem worse than the attempted prophylactic fix (Macdonald, 2016).

A recent study in the leading *Journal of Public Health* found "more and more experts are beginning to question whether the majority of these surgeries are even necessary. And a growing body of research indicates that we might be putting people through the risk of expensive tooth removal for no reason" (Friedman, 2007, p. 1554). After not-

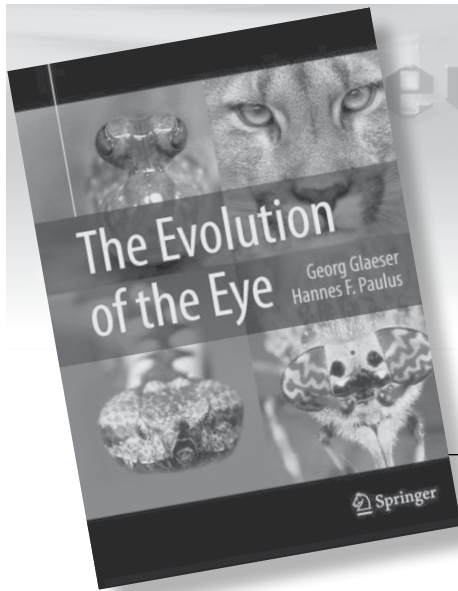
ing that, in some cases, their removal is necessary, Friedman adds that especially prophylactic removal can be a problem: "these extractions, associated costs, and injuries are unnecessary, constituting a silent epidemic of iatrogenic injury that afflicts tens of thousands of people with lifelong discomfort and disability" (Friedman, 2007, p. 1554). These examples are only two of many that illustrate the fallacious line of evidence Ra used to build his case.

Last, it is my observation that Aron Ra, who as far as I could determine, does not have an advanced degree, or any degree in a biological field, did not study the subject of his book carefully before he wrote it. He relies heavily on his fellow atheists as well as committed Darwinists and shows, at best, a very weak knowledge of creation arguments.

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The Evolution of the Eye

by Georg Glaeser and
Hannes F. Paulus

Springer, New York, 2015, 214
pages, \$43.00

One logically expects a book titled *The Evolution of the Eye* to thoroughly cover the topic. Although the authors add the word evolution in several places, the book does not include evidence for eye evolution, probably because, aside from speculation, there exists no empirical evidence. Rather, this book should be titled *The Wonders of Eye Design*. This title would be more accurate and may have resulted in improved sales. Some of the reviews on Amazon mention this same point.

If you have any interest in the complexity of eye design and variations, or the general topic of vision, this book is excellent, especially the beautiful color illustrations on almost every page. It contains a detailed discussion and scores of photographs of the incredible variety of eyes existing in the natural world, and the enormous variations of eye design, plus much interesting trivia about eyes and vision. One takeaway is the wide variety of eye designs—hundreds at last count—existing in the natural world and how they function to maximize vision in the animals' environment.

When read carefully, the book provides clear evidence against evolution. For example, the authors stress that many types of eyes exist, and each one is specially designed to maximize the life-form's ability to thrive in its specific

environment. Animals either have fully functional eyes or lack them altogether, nothing in between. Even so-called simple eyes, the authors show, are very complex. Conversely, it is noted that in spite of vertebrates' profound body size differences, from inches-in-length to yards-long, eyeballs are all very close to the same relative size, and none are larger than a tennis ball, even for the largest known animal, the whales (p. 2).

The reason is, besides design constraints and the very efficient eye design existing in all life, the size of even the smallest eye is large enough to take in the amount of light necessary to achieve the sight goal the animal requires to thrive in its environment. Although the light sensor of a phone camera is about the size of a pin head, due to its design it can take pictures of equal or better quality than the expensive 35-mm film single lens reflex cameras used a decade ago. Likewise, the eyeball sensors do not need to be larger due to the effective design of each existing animal's vision system.

For obvious reasons, nocturnal animals like cats have larger eyes than the same-sized diurnal animals to take in more light (p. 88). Cats also have a tapetum lucidum at the back of their retina which reflects light that has passed beyond the rods and cones to "reuse it." This system improves night vision and produces the glowing "cat's eye" when automobile lights shine on them (p. 91). The cat's slit-shaped pupil allows light to

pass through a large cross section of the lens's concentric ring onto a large area of their retina in contrast to the pin-hole type pupil eyes such as humans use.

The authors cover evolution in general on pages 146–149 and apply it to eyes, but even here they only repeat the usual speculations and assumptions commonly made by Darwinists. The authors note the development of eyes from simplest known to the most complex, from insects' compound eyes to the camera eye, with its enclosed structure, its iris and lens, liquid interior, and its image-sensing retina regulated by the Pax6 gene. No evidence exists of the evolution of this central control system that evolutionists expect would vary from simple to complex over time. Contrary to the Darwinists' prediction, the development system that produces the eye is close to being equally-complex in all eyes.

Another design that fits perfectly to an animal's environment is an eye system that can see both in the air and in the water, requiring a design that combines two different eye types into one eye. The problem that must be solved is air and water have different refractive indexes, affecting the focusing of the eye. On land, a curved cornea suffices, but use of a special auxiliary lens is required to see underwater (pp. 128–129). Another solution is the split eyes of four-eyed fish, called such because each eye is split by horizontal partitions into two halves.

Each half has its own specially designed cornea, iris, and retina, allowing it to simultaneously see both above and below the water surface (pp. 126, 134, 211).

Yet another design appears in the whirligig beetle, which hunts while floating on the water surface (pp. 129, 152). It has four eyes, one set submerged underwater to hunt for prey while the other set is above the water to watch for predators. One eye set is designed to match the refractive index of air and the other matched water, allowing them to observe objects above and below water simultaneously without compromising focusing sensitivity.

Another eye design to improve vision is a system that maximizes sensitivity to specific light frequencies. An example is the eye of the elephant seal, which is most sensitive to blue light. Also, one type of butterfly has in its retina 15 different cone types, five times as many color-sensing cell types compared to humans, which have only three—red, green, and blue. As a whole, butterflies and moths often have far more sophisticated color vision than humans.

The book is filled with similar eye design variations, and not a clue is given how the animal could, by small mutational-caused changes, come up with the ingenious designs existing in nature, except to say that evolution is solely responsible. One example is Haeckel's now disproven "ontogeny repeats phy-

logeny" embryo evidence of evolution, covered in an attempt to show "all stages of eye evolution" exist in the developing fetus and embryo (p. 14). The authors acknowledge that Haeckel's idea was oversimplified, but they do not explain or tell the whole sad story. They even claim humans recapitulate fish gills during our embryonal development (p. 4).

The authors repeatedly personify evolution to explain eye design, implying that if a need exists, evolution gets to work to determine the specific design required, and then solve the problem, often employing ingenious solutions. Some examples include animals that "must see well in and outside of water [and] have to evolve special adaptations" (p. 126). Most "arthropods have facet eyes, from which spiders, in a secondary feat of evolution, have managed to evolve lens eyes" (p. 4). "Both lens and facet eyes were 'invented' multiple times throughout animal history" (p. 18). "In order to utilize what little light is available many species have evolved barrel eyes" (p. 81). "The lens eyes produced by evolution almost always exhibit a built-in 'auxiliary lens'" (p. 129). I found, in a review of articles on eye evolution, that this personification is very common, again largely because Darwinists have no other explanation.

One example is this: "Eyes and wings are among the most stunning innovations evolution has created. Remarkably

these features have evolved multiple times in different lineages of animals ... Pax6 RNA splicing in cephalopods is a wonderful demonstration of how evolution fashions equivalent solutions via entirely different routes. Using analogous structures, evolution can provide remarkable innovations" (Campbell, 2014).

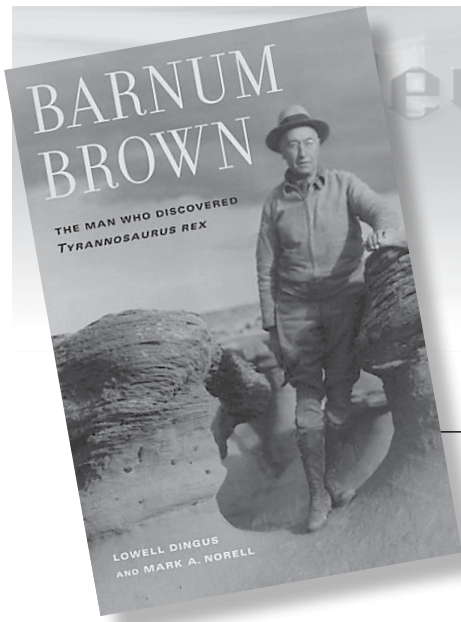
Chapter 8 is on alternative senses, including smell, to enable effective navigation and hunting in darkness. The systems covered include electrical, thermal, magnetic-field sensitivity, and the vomeronasal organ system that forwards information from specific chemical signals called pheromones to the central nervous system for interpretation.

One final complaint is that the book is perfect bound, meaning the pages are glued, but should have been stitched to allow opening the pages wider to view the photographs and text near the binding.

Reference

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Barnum Brown: The Man Who Discovered Tyrannosaurus rex

by Lowell Dingus
and Mark A. Norell

University of California Press,
Berkeley, 2010, 368 pages,
\$29.25

Whether seen in a book at home or at a museum, nearly every child recognizes the grand form of *Tyrannosaurus rex*, but few know the story of the equally legendary paleontologist Barnum Brown. Described as “one of the three Kings of Dinosauria” (Bird, 1985, p. 28), this larger-than-life figure grew to prominence as a renowned world traveler and master of Dinosauria, lovingly bestowed the title ‘Mr. Bones’ by individuals across the nation. This biography by paleontologists Lowell Dingus and Mark A. Norell eloquently conveys the life history of one of the greatest dinosaur hunters of America, thereby bridging a gap in the current literature on twentieth century dinosaur paleontology (Naish, 2012).

Born and raised on a small Kansas farm in the late nineteenth century, Brown’s insatiable interest in the natural world grew unabated as he investigated the surrounding hills. While at the University of Kansas, Brown began his lifelong career as a fossil collector, eventually joining the prestigious American Museum of Natural History (AMNH) for which he spent the rest of his career. A true world traveler, Brown prospected throughout Patagonia, Europe, India, and across the North American conti-

nent, collecting and naming numerous specimens, not least the discovery of *Tyrannosaurus rex*. An occasional author, Brown accumulated an impressive list of articles by the end of his career, especially considering his position in the AMNH (p. 71).

This glimpse into the life of Brown not only provides keen insights into early twentieth century paleontology, but also into the lives of other prominent figures, including Roy Chapman Andrews, Walter Granger and Charles H. Sternberg. Another renowned colleague of Brown was the flamboyant Henry Fairfield Osborn. As president of the AMNH, Osborn had become one of the greatest American promulgators of evolution. He was a man of plentiful contradictions—his era’s greatest spokesperson for evolution yet was distinctly non-Darwinian, and an ardent racist who denied a bestial origin of humanity. However, Osborn had an inordinate interest in human evolution stemming in part from his desire to substantiate his ideas for an Asiatic origination of earliest civilization. This interest in human evolution inevitably led to rhetorical feuds with fellow political titan, William Jennings Bryan, whom he would later oppose in the Scopes Trial. This difference of ideologies instilled in Osborn a passionate personal and professional rivalry against Bryan. This rivalry would soon commence one of the greatest

blunders in the history of paleontology as Osborn searched for the earliest vestiges of humanoid evolution.

Geologist Harold Cook addressed a letter to Osborn in 1922 containing a single Pliocene tooth Cook had discovered in Nebraska. Osborn quickly pronounced it to be an anthropoid remnant closely allied to man’s earliest ancestor. Just a month later, Osborn published a description in *Nature* dubbing the find ‘*Hesperopithecus haroldcookii*’. Nebraska Man, as this alleged anthropoid was soon called, served as a double-pronged attack on Bryan by providing supposed evidence of human evolution from Bryan’s own home state. It was not long, however, before some began to doubt the accuracy of the tooth’s classification. In 1925, Osborn sent both Brown and Albert Thomson for further investigations in Nebraska. In June of that year, Brown warned Thomson in a letter that “[i]t is quite possible that these teeth are an undescribed form of [the pig-like organism] ‘peccary’” (p. 231; brackets mine). Osborn himself began to doubt the supposed anthropoid origin of the tooth, illustrated by the lack of its mention at the Scopes Trial the following month. Five years after Osborn’s preliminary publication, the tooth’s classification as *Hesperopithecus* was publicly falsified by one of Osborn’s own lab scientists and Nebraska Man went down as a major error in paleontology (pp. 231–232).

Despite this, some continue to use Nebraska Man as evidence of human evolution contrary to the overwhelming data against an anthropoid origination (Sibley, 2008).

In contrast to his initial collection of bones at the commencement of his career, Brown turned to excavating tracks through the 1930s and 40s with the assistance of his protégé and right-hand man R. T. Bird. One particularly noteworthy trackway was discovered in the roof of the States Mine near Cedaredge, Colorado, containing positive hyporelief of tracks from an unidentified bipedal dinosaur initially measured at 5 m strides. Thrilled with the find, Brown remarked “People would never believe the stride, unless we bring back all the rock [in] between [each track]” (Bird, 1985, p. 104; brackets mine). A wise decision, for later examination demonstrated there was a track intermediate to the others, bringing the stride’s length down to 2.5 m (p. 268). This series of incidents illustrate one of the foundational principles of track collection—never trust solitary tracks, especially when they are no longer in situ!

After excavating the tracks of the “Mystery Trackmaker” in Colorado, Brown and Bird turned their attention southeast to Glen Rose, Texas, and the Paluxy River to investigate theropod tracks. These tracks became insignificant as some of the world’s first

sauropod trackways were discovered nearby. Further excavation revealed the additional trails of several sauropods possibly comprising a family group. This discovery assisted the transformation of sauropods from lacustrine to terrestrial as their preferred environment. But, as it is today, the Glen Rose tracks were not without contention. Some claimed to have found tracks of ginormous humans in the same strata that contained dinosaur tracks. Interested in these assertions, Bird (1985, p. 147) examined several solitary humanoid and theropod tracks in the nearby towns, noting that both human and dinosaurian tracks were “suspiciously too perfect” to be authentic. Bird continued: “When a beast pulls a claw out of mud, he doesn’t leave a perfect copy; the mud slurps about a bit. The fact that man appeared something better than sixty million years after the dinosaurs left stamped ‘Fraud’ on all this artists’ [sic] work” (p. 147). Indeed, quarrying tracks was a common occupation for the locals along the Paluxy River. Although Bird’s prejudice against contemporaneity of humans and dinosaurs is evident, his analysis bolsters the conclusions of other critiques (e.g. Morris, 2013; Silvestru, 2004; and references therein), necessitating caution before the Glen Rose tracks are used as evidence of coexistence between dinosaurs and humans (Walker, 2019).

This book masterfully analyses a vast repertoire of resources to bring into sharp focus the life and work of one of the greatest dinosaur hunters of his time. Furthermore, it offers an important perspective on the historical and political climate of Brown’s day, making it a prime resource for Diluvialist research. Whether for research or pleasure, this book is certain to entertain its reader.

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A Tour of the Smithsonian Hall of Fossils

Washington D.C., 2019

In the Smithsonian Natural History Museum, the David H. Koch Hall of Fossils reopened in June 2019 after 5 years closure for remodeling. This museum hosts millions of visitors each year. There is no charge for admission; tax dollars provided the \$110 million for the makeover. I have given many creation tours there over the years, so I was very interested in checking out the new displays. Since this is the people's museum, there are no prohibitions concerning freedom of speech. I have often enjoyed giving creation comments to my groups and having others gather around to listen as well. On a recent visit, I enjoyed interacting with other visitors and a docent. The following is a review of the new display.

As you enter the hall of fossils, the first sign reads "Journey through Deep Time." Next to it are smaller signs, "Discover your impact on life's epic story today and into the future;" "Exploring earth's distant past helps us understand the present and plan our future;" "Explore how life evolved as the world changed;" and "Travel back to the origins of life on earth." The designers clearly want to make this part of the museum not only interesting but also relevant.

The fossil hall is vastly different from the previous—brighter and more upbeat. Visitors start at the present and move into the deeper and deeper past in reverse evolutionary order.

A sign near the seal and penguin fossils (which look just like today's or-

ganisms) states, "Sometimes unrelated species evolve similar features for living in particular environments or performing certain functions. You'll see many examples of this convergent evolution as you travel back in time through the exhibition." The assumption is that many features that were unlikely to have evolved by chance once, supposedly managed to evolve multiple times.

The *Diatryma* fossil shows a large extinct bird with an enormous beak, earlier thought to be a carnivore that hunted small horses. A sign states, "Newer evidence...suggests that it may have eaten plants." One might suggest that all big-toothed animals were originally plant eaters.

For sea cow evolution, a sketch of "one of the earliest sea cows" shows it with four complete legs. Next to the sketch is another showing a sea cow with two fore-flippers, a fluked tail, and no hind legs at all (like today's sea cows). I believe that if any intermediate fossils were known, they would have been pictured.

A beautiful fossil of "an early species of horse" is on a slab from the Green River Formation. Several fossilized fish are embedded near the horse. The museum sign indicates the horse likely floated out into a lake after dying. Such perfect preservation of a horse and fish demands rapid burial involving both terrestrial and aquatic organisms. However, there is no mention of a catastrophe, so the reader is given the impression that a dead horse peacefully floated out into a lake, eventually sank, and was slowly buried and fossilized along with the fish.

I noticed the following quote from Darwin's *Origin of Species* in three separate areas of the fossil hall: "From so

simple a beginning endless forms most beautiful and wonderful have been, and are being, evolved." In this view, the beauty and wonder we experience in nature is all due to random processes. Another sign reads that Darwin "...discovered that all species of life have descended over time from a common ancestor through the process of evolution by natural selection. Today his groundbreaking work is the foundation of all the biological sciences." The word, "discovered" means he found empirical evidence for this overarching, universal statement. The only place where this could be "discovered" would be in the fossil record, which Darwin admitted was the gravest problem with his idea. Perhaps *imagined* would have been a more appropriate word than "discovered." Next to this Darwin sign is his life-sized bronze statue as a young man, seated, and looking up in wonder with notebook in hand. On his shoulder is perched a bird, no doubt a finch. The portrait of Darwin as a nature lover contrasts sharply with the fact that in his youth he was an avid bird hunter. What we have is an attempt to re-package Darwin to make him environmentally friendly.

A sign reads, "Several different groups of land-living turtles moved to the sea. Each independently evolved a streamlined body with flippers and a reduced shell."

"Flowering Plants: A Wild Success" declares a sign. There is no mention of how Darwin viewed flowering plant evolution as an "abominable mystery."

According to an elaborate display, we now know what caused the Permian extinction when up to 90 percent of marine species supposedly vanished. That is, massive volcanic eruptions released carbon



dioxide into the atmosphere. This caused global warming, a decrease in oxygen, and the oceans becoming more acidic. "These changes led to worldwide extinctions, mostly in marine ecosystems." I would think that marine ecosystems would be the least affected by this acid rain, especially benthic regions where organisms like trilobites were eliminated. As an alternative, the breaking up of all the fountains of the great deep would rapidly bury and fossilize these creatures worldwide.

For mankind, "The evidence is clear: We are causing rapid, unprecedented change to our planet. But there is hope—we can adapt, innovate, and collaborate to leave a positive legacy...Billions of informed citizens acting together can create a sustainable world...our ingenuity can help us find solutions that are collective and global." Hopefully creationists and evolutionists will agree human activities have caused environmental damage.

Regarding mammals and dinosaurs. A sign states, "Dinosaurs shared the world with mammals...In many Jurassic ecosystems, there were more species of

mammals than dinosaurs." It's heartening to know that the "age of reptiles" myth has finally come to an end.

How does evolution work? A large display attempts to explain using dinosaurs as examples. A phylogenetic tree shows two branches (Ornithischians and Saurischians), with an example of each, emerging from "the earliest dinosaurs." However, this putative ancestor of all dinosaurs has no name assigned to it. So, the identity of the first dinosaur remains a mystery. So, "how does evolution work? Evolution is the natural process by which life changes over time. It starts with small differences that occur in species from one generation to the next. Over many generations, these can accumulate into larger differences, leading to new species. Over millions of years, entirely new lineages and groups of plants and animals arise this way."

For human evolution, there is an interactive exhibit in which a robotic girl explains, when prompted, the evolutionary origin of eight separate human features including lungs, head, mitochondria, opposable thumb and belly button. This is designed to appeal to children with

nothing to indicate the tentative nature of science. The conclusion—"Your body holds the evidence of your evolutionary journey...Your body is the result of 3.7 billion years of evolution."

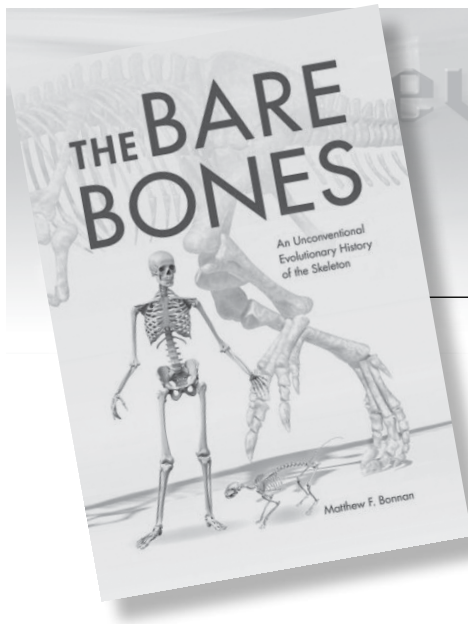
Regarding trilobites, "Their three-part shell of calcium carbonate housed sophisticated eyes and jointed legs." We are told that they endured for 250 million years, starting in the Cambrian Period. There is no mention of their ancestor or what caused trilobite extinction.

In a final display it is stated, "Every living thing on earth evolved from a single species...What is life? On early earth, life arose as three essential ingredients emerged and combined...Life equals cell with a membrane plus genetic information plus metabolism."

Changing the hall of fossils from a dark area to a bright, open environment is a positive upgrade. One thing has not changed, the pervasive treatment of evolution as established fact.

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The Bare Bones: An Unconventional Evolutionary History of the Skeleton

by Matthew Bonnan

Indiana University Press,
Bloomington, IN, 2016,
510 pages, \$75.00.

Author Bonnan, Professor of Biology at Stockton University, New Jersey, attempts to produce a readable, user-friendly retelling of what he calls the greatest story in evolution, the rise of vertebrates. The key is the evolution of bone, thus the title of the book. Bonnan uses many illustrations and stories to illustrate his ideas and convert the reader to the evolutionary worldview. He also discusses why he feels it is important to respond to opposing arguments.

Reading this book helps one understand how young people can be converted from a creation to an evolutionary worldview. The author largely ignores the creation issue, and even begins his book almost apologizing for evolution, using the well-worn “science vs. religion claim.” The issue, he argues, is not accepting either evolution or religion (he uses the word spirituality) but, Bonnan asserts, evolution answers different questions than religion (p. 9). Evolution, he asserts, answers the ‘what’ while God answers the ‘who.’

Bonnan uses the example of an automobile repairman who is concerned with understanding the mechanics of automobiles, which, Bonnan adds, has nothing to do with the question

of whether God exists. Bonnan asserts that evolution likewise concerns itself with the origin of all life forms, not spiritual questions. The comparison breaks down when phrased as follows: The mechanic may be concerned with understanding how to fix automobiles, just as a doctor is concerned with fixing a diseased body but, in contrast, evolution is concerned with the actual origin of the body itself, giving a very different answer to this question than a creationist. One example of this difference Bonnan provides is an illustration facing showing a photograph of a man (the author?) who is described as a “Clothed Bipedal Ape” (p. 22).

Bonnan defines evolution as descent with modification, and notes that the source of genetic variation is mutations (p.11). He neglects the fact that close to 99 percent of all mutations are deleterious, harmful, or near neutral, meaning they accumulate to the point of causing damage and are lethal to evolution theory. Bonnan notes that “the theory of biological evolution predicts that vertebrate animals alive today and those contained in the fossil record, are descendants of a single common ancestor” presumably some type of amphioxus. This is the term I learned in zoology while Bonnan uses was term lancelet (p. 33).

Although amphioxus are considered the most primitive chordate, they lack bones (p. 36). The most primitive living vertebrate, and thus the origin of the vertebrate chassis, are the hagfish and lamprey. Lampreys have a cartilaginous

skeleton as do the cartilaginous fish (those in the class Chondrichthyes) which presumably evolved into the Osteichthyes (or bony fish), thus where the first bone evolved. Consequently, the key to the evolution of bone is the link between these two similar fish. Cartilaginous fish have a skeleton made up entirely of cartilage while bony fish have a skeleton made up of the bones we see in most higher-level vertebrates.

Bonnan mentions evolution 146 times, and every example is how one bone, such as a limb bone, evolved into a limb bone in another kind of animal. He never mentions how the pre-bone, whatever that was, evolved into bone, which is the real issue and the reason I bought the book. The author never mentions the problem of bone evolution from non-bone, not even a theory to explain this mysterious event he calls an evolutionary “explosion.” Once bone evolved, Osteichthyes fish, amphibians, birds, reptiles, mammals and primates could evolve, and not until then. The book assumes vertebrate evolution and then postulates the changes required in the design from the simplest to the most complex animal.

The book is very well written and easy to follow. It contains much good information and will serve as an excellent reference. I was impressed with this book, and, in spite of weaknesses, recommend it to others.

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Manuscripts shall be computer-printed or neatly typed. Lines should be double-spaced, including figure legends, table footnotes, and references. All pages should be sequentially numbered. Upon acceptance of the manuscript for publication, an electronic version is requested (Word, WordPerfect, or Star-Office/Open Office), with the graphics in separate electronic files. However, if submission of an electronic final version is not possible for the author, then a cleanly printed or typed copy is acceptable.

Submitted manuscripts should have the following organizational format:

1. Title page. This page should contain the title of the manuscript, the author's name, and all relevant contact information (including mailing address, telephone number, fax number, and e-mail address). If the manuscript is submitted by multiple authors, one author should serve as the corresponding author, and this should be noted on the title page.

2. Abstract page. This is page 1 of the manuscript, and should contain the article title at the top, followed by the abstract for the article. Abstracts should be between 100 and 250 words in length and present an overview of the material discussed in the article, including all major conclusions. Use of abbreviations and references in the abstract should be avoided. This page should also contain at least five key words appropriate for identifying this article via a computer search.

3. Introduction. The introduction should provide sufficient background information to allow the reader to understand the relevance and significance of the article for creation science.

4. Body of the text. Two types of headings are typically used by the *CRSQ*. A major heading consists of a large font bold print that is centered in column, and is used for each major change of focus or topic. A minor heading consists of a regular font bold print that is flush to the left margin, and is used following a major heading and helps to organize points within each major topic. Do not split words with hyphens, or use all capital letters for any words. Also, do not use bold type, except for headings (italics can be occasionally used to draw distinction to specific words). Italics should not be used for foreign words in common usage, e.g., "et al.", "ibid.", "ca." and "ad infinitum." Previously published literature should be cited using the author's last name(s) and the year of publication (ex. Smith, 2003; Smith and Jones, 2003). If the citation has more than two authors, only the first author's name should appear (ex. Smith et al., 2003). Contributing authors should examine this issue of the *CRSQ* or consult the Society's web site for specific examples as well as a more detailed explanation of manuscript preparation. Frequently-used terms can be abbrevi-

ated by placing abbreviations in parentheses following the first usage of the term in the text, for example, polyacrylamide gel electrophoresis (PAGE) or catastrophic plate tectonics (CPT). Only the abbreviation need be used afterward. If numerous abbreviations are used, authors should consider providing a list of abbreviations. Also, because of the variable usage of the terms “microevolution” and “macroevolution,” authors should clearly define how they are specifically using these terms. Use of the term “creationism” should be avoided. All figures and tables should be cited in the body of the text, and be numbered in the sequential order that they appear in the text (figures and tables are numbered separately with Arabic and Roman numerals, respectively).

5. Summary. A summary paragraph(s) is often useful for readers. The summary should provide the reader an overview of the material just presented, and often helps the reader to summarize the salient points and conclusions the author has made throughout the text.

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Robinson, D.A., and D.P. Cavanaugh. 1998. A quantitative approach to baraminology with examples from the catarrhine primates. *CRSQ* 34:196–208.

Lipman, E.A., B. Schuler, O. Bakajin, and W.A. Eaton. 2003. Single-molecule measurement of protein folding kinetics. *Science* 301:1233–1235.

Margulis, L. 1971a. The origin of plant and animal cells. *American Scientific* 59:230–235.

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Hitchcock, A.S. 1971. *Manual of Grasses of the United States*. Dover Publications, New York, NY.

Walker, T.B. 1994. A biblical geologic model. In Walsh, R.E. (editor), *Proceedings of the Third International Conference on Creationism* (technical symposium sessions), pp. 581–592. Creation Science Fellowship, Pittsburgh, PA.

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not embed figures in the text. Each figure should contain a legend that provides sufficient description to enable the reader to understand the basic concepts of the figure without needing to refer to the text. Legends should be on a separate page from the figure. All figures and drawings should be of high quality (hand-drawn illustrations and lettering should be professionally done). Images are to be a minimum resolution of 300 dpi at 100% size. Patterns, not shading, should be used to distinguish areas within graphs or other figures. Unacceptable illustrations will result in rejection of the manuscript. Authors are also strongly encouraged to submit an electronic version (.cdr, .cpt, .gif, .jpg, and .tif formats) of all figures in individual files that are separate from the electronic file containing the text and tables.

Special Sections

Letters to the Editor:

Submission of letters regarding topics relevant to the Society or creation science is encouraged. Submission of letters commenting upon articles published in the *Quarterly* will be published two issues after the article's original publication date. Authors will be given an opportunity for a concurrent response. No further letters referring to a specific *Quarterly* article will be published. Following this period, individuals who desire to write additional responses/comments (particularly critical comments) regarding a specific *Quarterly* article are encouraged to submit their own articles to the *Quarterly* for review and publication.

Editor's Forum:

Occasionally, the editor will invite individuals to submit differing opinions on specific topics relevant to the *Quarterly*. Each author will have opportunity to present a position paper (2000 words), and one response (1000 words) to the differing position paper. In all matters, the editor will have final and complete editorial control. Topics for these forums will be solely at the editor's discretion, but suggestions of topics are welcome.

Book Reviews:

All book reviews should be submitted to the book review editor, who will determine the acceptability of each submitted review. Book reviews should be limited to 1000 words. Following the style of reviews printed in this issue, all book reviews should contain the following information: book title, author, publisher, publication date, number of pages, and retail cost. Reviews should endeavor to present the salient points of the book that are relevant to the issues of creation/evolution. Typically, such points are accompanied by the reviewer's analysis of the book's content, clarity, and relevance to the creation issue.

Creation Research Society

Membership/Subscription Application and Renewal Form

The membership/subscription categories are defined below:

1. **Voting Member** Those having at least an earned master's degree in a recognized area of science.
2. **Sustaining Member** Those without an advanced degree in science, but who are interested in and support the work of the Society.
3. **Student Member** Those who are enrolled full time in high schools, undergraduate colleges, or postgraduate science programs (e.g., MS, PhD, MD, and DVM). Those holding post-doctoral positions are not eligible. A graduate student with a MS degree may request voting member status while enrolled as a student member.
4. **Senior Member** Voting or sustaining members who are age 65 or older.
5. **Life Member** A special category for voting and sustaining members, entitling them to a lifetime membership in the Society.
6. **Subscriber** Libraries, churches, schools, etc., and individuals who do not subscribe to the Statement of Belief.

All members (categories 1–5 above) must subscribe to the Statement of Belief as defined on the next page.

Please complete the lower portion of this form and mail it with payment to CRS Membership Secretary, 6801 N. Highway 89, Chino Valley, AZ 86323, or fax for credit card payment to (928) 636-1153. Applications may also be completed online at creationresearch.org.



This is a ☐ new ☐ renewal application for the subscription year beginning Summer ☐ 2018 ☐ _____. (Please type or print legibly.)

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☐ Life member	☐ \$500	☐ \$500	☐ \$500	☐ \$500
☐ Student* [per year]	☐ \$38	☐ \$58	☐ \$75	☐ \$28
☐ Subscriber [per year]	☐ \$46	☐ \$66	☐ \$83	☐ \$36
* Student members are required to complete the bottom portion of this form. NOTE: Student members may qualify for the <i>Future Leaders Sponsorship</i> program. See the CRS website at www.creationresearch.org for details. ** Rates for the paper option include postage for First Class Mail International				

† **PAPERLESS option:** You may opt out of receiving paper copies of the CRS periodicals (*CRS Quarterly* and *Creation Matters*). By choosing this option you may register for access to the Premium Area of the website, where you may view or download electronic (PDF) versions of these publications. Of course, regular members and subscribers may also have access to the Premium Area. Only members, however, will have access to the Members Exclusive Area of the website.

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Creation Research Society

History—The Creation Research Society was organized in 1963, with Dr. Walter E. Lammerts as first president and editor of a quarterly publication. Initially started as an informal committee of 10 scientists, it has grown rapidly, evidently filling a need for an association devoted to research and publication in the field of scientific creation, with a current membership of over 600 voting members (graduate degrees in science) and about 1000 non-voting members. The *Creation Research Society Quarterly* is a peer-reviewed technical journal. It has been gradually enlarged and modified, and is currently recognized as one of the outstanding publications in the field. In 1996 the CRSQ was joined by the newsletter *Creation Matters* as a source of information of interest to creationists.

Activities—The Society is a research and publication society, and also engages in various meetings and promotional activities. There is no affiliation with any other scientific or religious organizations. Its members conduct research on problems related to its purposes, and a research fund and research center are maintained to assist in such projects. Contributions to the research

fund for these purposes are tax deductible. As part of its vigorous research and field study programs, the Society operates The Van Andel Creation Research Center in Chino Valley, Arizona.

Membership—Voting membership is limited to scientists who have at least an earned graduate degree in a natural or applied science and subscribe to the Statement of Belief. Sustaining membership is available for those who do not meet the academic criterion for voting membership, but do subscribe to the Statement of Belief.

Statement of Belief—Members of the Creation Research Society, which include research scientists representing various fields of scientific inquiry, are committed to full belief in the biblical record of creation and early history, and thus to a concept of dynamic special creation (as opposed to evolution) both of the universe and the earth with its complexity of living forms. We propose to re-evaluate science from this viewpoint, and since 1964 have published a quarterly of research articles in this field. *All members of the Society subscribe to the following statement of belief:*

1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.

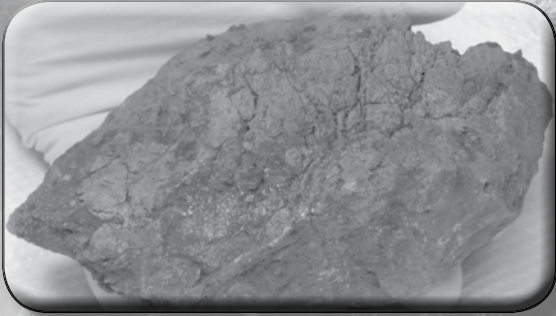
2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.

3. The Great Flood described in Genesis, commonly referred to as the Noachian Flood, was a historical event worldwide in its extent and effect.

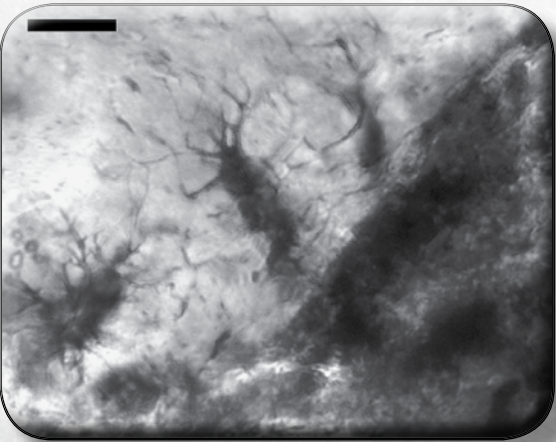
4. We are an organization of Christian men and women of science who accept Jesus Christ as our Lord and Savior. The act of the special creation of Adam and Eve as one man and woman and their subsequent fall into sin is the basis for our belief in the necessity of a Savior for all people. Therefore, salvation can come only through accepting Jesus Christ as our Savior.

iDINO II

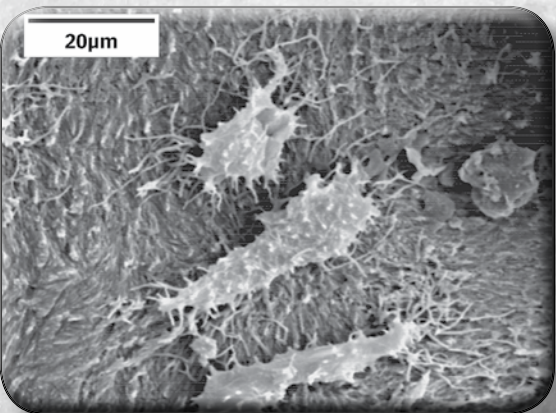
Investigation of Dinosaur Intact Natural Osteo-tissue



A fragment of the *Triceratops* brow horn.
Fragments, such as this one,
still contain tissue and cells.



Microscopic examination of tissue
extracted from a *Triceratops* horn
reveals bone cells still present.



Electron microscope picture of
intact bone cells still in tissue
extracted from a *Triceratops* horn.

How can pliable, stretchable tissue survive inside dinosaur fossils for over 65 million years?

How can this tissue still contain intact cells and even dinosaur proteins?

How can this fragile biological material survive for so long?

The answer to these questions directly challenges the current, evolutionary-biased, geologic timescale.

The Creation Research Society began its iDINO research initiative for the purpose of studying soft tissue in dinosaur fossils. The first phase of the project detected pliable, unfossilized tissue in a brow horn of a *Triceratops*. Within this tissue were intact osteocytes (bone cells). Some results from the iDINO project have been published in a technical microscopy journal and presented at an international microscopy conference. The Spring 2015 issue of the *Creation Research Society Quarterly* also features a special report of the iDINO project. Plus, to further spread the important information about soft tissue, the Society is developing a video (Echoes of the Jurassic).

The **second phase** of the project (iDINO II) will look more extensively at the process of tissue preservation. Evolutionists have offered various theories of how this tissue could survive for millions of years. iDINO II will methodically investigate these preservation claims, assessing their plausibility.

The iDINO results have already provided a strong challenge to the evolutionary worldview. More extensive and detailed examination may provide even stronger evidence that the age of dinosaur fossils is far less than 65 million years. To this end, the Society continues to seek those willing to fund this project with either one-time gifts or monthly donations.

For more information contact us at (928) 636-1153 or crsvarc@crsvarc.com.

Also visit <http://tinyurl.com/nphm2c4> for project updates and details.